TEN NEW ENGLAND BLOSSOMS

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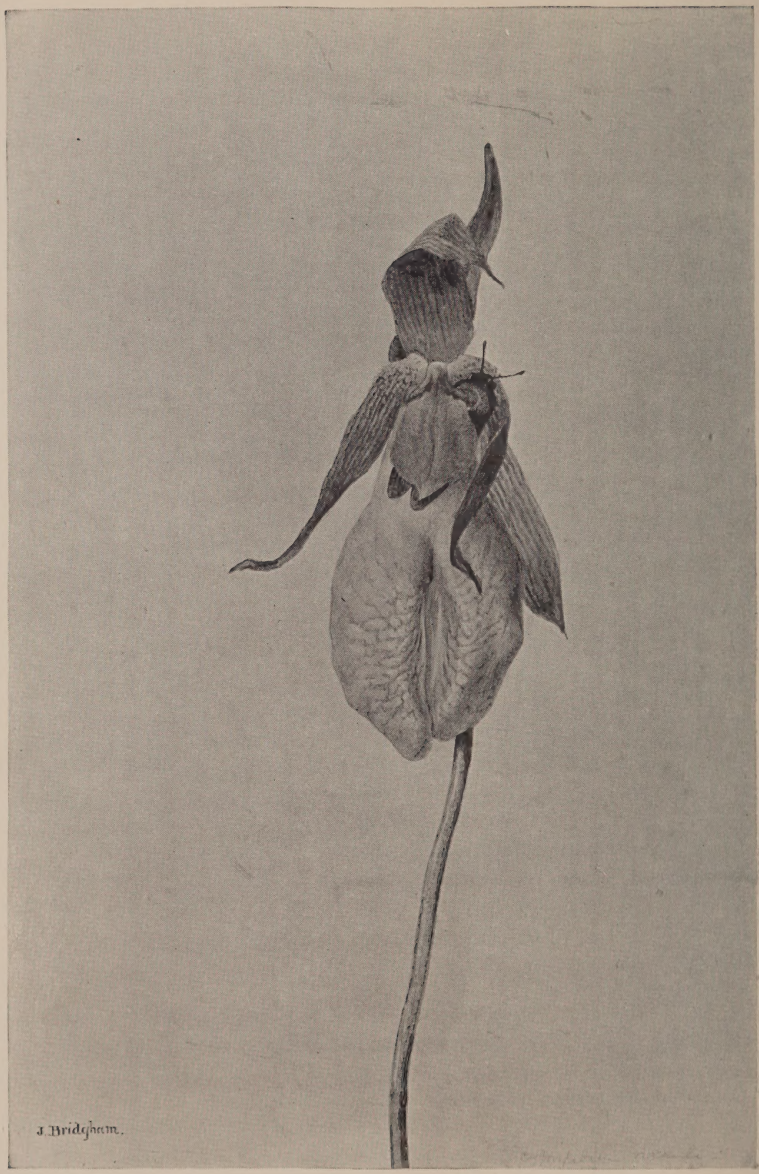

A Floral Tragedy.

TEN NEW ENGLAND BLOSSOMS AND THEIR INSECT VISITORS

BY

CLARENCE MOORES WEED

The enchanted world of Botany, where the flowers for reasons of their own strive to grow hourly more beautiful. — SIR EDWIN ARNOLD

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TO

MY LITTLE DAUGHTER IRENE

FOR ME THE MOST CHARMING OF NEW ENGLAND BLOSSOMS

THESE NATURE-STUDIES

ARE INSCRIBED

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The photographs reproduced in this book were taken by Dr. H. H. Lamson, Mr. H. H. H. Langill, and Messrs. Drew and Boomer. Most of the original sketches were drawn by Mr. W. E. Britton under the author's supervision.

To watch uninterruptedly the same few yards of universe unfold its complex history; to behold the hourly resurrection of new living things and miss no change or circumstance even of its minuter parts; to look at all, especially the things you have seen before a hundred times, to do all with patience and reverence — this is the only way to study nature. — DRUMMOND.

The older I grow the more I am convinced that there are no satisfactions so deep and so permanent as our sympathies with outward nature. I have not said just what I meant, for we are thrilled even more by any spectacle of human heroism. But the others seem to bind our lives together by a more visible and unbroken chain of purifying and softening emotion. In this way the flowering of the buttercups is always a great, and, I may truly say, religious event in my year. — LOWELL.

TEN NEW ENGLAND BLOSSOMS

I

THE GLAUCOUS WILLOW

While from time immemorial we have known that flowers are of great importance to insects, it is only comparatively of late that we have realized how important, indeed how necessary, insects are to flowers. For it is not too much to say, that if, on the one hand, flowers are in many cases necessary to the existence of insects, insects, on the other hand, are still more indispensable to the very existence of flowers: — that if insects have been in many cases modified and adapted with a view to obtain honey and pollen from flowers, flowers in their turn owe their scent and their color, their honey, and even their distinctive forms, to the action of insects. — *Lubbock.*

Every one who has paid any attention to the higher plants knows that there are two sets of organs in flowers essential to the reproduction of the species. The pistil contains the embryo seeds, which do not develop unless fertilized by the pollen from the stamens. In many plants these two sets of organs occur in the same flower, but in others they are found on different parts of the

plant, or even on different plants. In the alder the staminate blossoms hang in long festoons from the

Alder Catkins.

smaller branches, while the pistillate ones project upward like little cones. In such a case some of the pollen, which is produced in great abundance, may

happen to fall from one of the drooping catkins on to the pistils, or else be blown to them by the wind. But in cases like the poplar, where each sort of blossom is borne on a different plant, it is evident that the pollen can rarely *fall* on the pistillate flowers: it must be transported in some other way. Two principal agencies may be called to the aid of such a plant: the pollen may be produced in great abundance and given to the winds to carry hither and thither in the expectation that a small proportion of the pollen-grains will finally lodge upon the pistils; or insects may be induced to visit the plant and carry the pollen from blossom to blossom. Each of these methods has been adopted: some plants are wind-pollenized or anemophilous; others are pollenized by insects and are said to be entomophilous. The former method, of course, is much the less economical of the two: millions of pollen-grains must be produced to be wasted for the few that are utilized.

The willows are entomophilous plants. They have called to their assistance a great variety of insects, which carry the pollen much more economically and effectively than would be possible had they depended upon the wind. The attraction by means of which insect visits are induced is fourfold, namely, color, odor, pollen, and nectar. The stami-

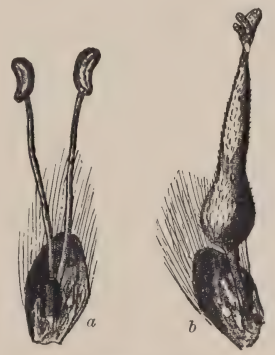
nate willow-blossoms possess a decided color due to the pollen and the anthers which contain them. In some species the ripening anthers assume bright pink or reddish tints, but when fully mature the yellow of the pollen is the conspicuous element. The catkins are massed together, and in the case of many species — like the Glaucous Willow (*Salix discolor*), with which we have especially to deal at this time — the flowers appear early in spring before the leaves expand, and so are much more conspicuous than they would be later in the season. The blossoms also possess a decided odor, which evidently serves to attract insects. Color and odor are the advertising agencies of the willow. They call the attention of the roaming bee or fly to the fact that nectar and pollen are at hand, to be had for the taking.

By pulling to pieces one of the staminate catkins of the willow, one sees that it is composed of a large number of individual flowers crowded together on a central axis. Each flower consists of a sheath-shaped piece, in front of which rise two long slender filaments that bear on their tips the anthers. In front of the base of these is the small oblong glandular body which secretes the nectar. In the pistillate blossoms (*b*) the two stamens are replaced by

a *b*

Staminate and Pistillate Willow Blossoms.

a single pistil, consisting of ovary, style, and stigma, with a nectary at the base. When a pollen-grain falls upon the stigma it sends out a little tube which penetrates the style until it reaches the ovule or embryo seed within the ovary. This is the process of fertilization. The process of pollination simply involves the carrying of the pollen from the stamens to the pistil.



Flowers of Willow.
a, staminate; *b*, pistillate.

The Glaucous Willow is one of the most abundant species of the genus in New England. It usually is a good-sized shrub, and occurs along ditches, creeks, roads, and fences. It blossoms early in the season, being one of the very first harbingers of spring, and is visited by large numbers of insects.

The little bees of the family Andrenidæ are much the most abundant of these spring callers. On bright days they come in swarms after honey and pollen. They are small insects, generally less than half as large as the common honey-bee. Their bodies, especially the head and thorax, are abundantly provided with hairs — full beards being fash-

ionable in this family, not only on the face but also on the shoulders and arms. The uses of this hirsute covering are at once apparent if you watch a bee upon the willow "pussies." You see it first reveling in the golden dust of the staminate catkins, thrusting its tongue down to the nectar, time and time again, till finally the pussy is plundered and the bee takes wing. Catch it now and you will see that the body is dusted all over with yellow pollen-grains, which are scattered promiscuously among the hairs. Put some of these hairs under a microscope of high power: each one reveals rows of barbs along its sides, among which the pollen-grains are fastened.

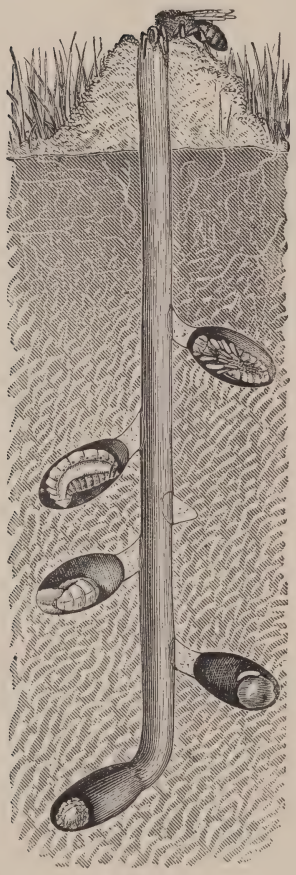
Hairs of Andrena, showing barbs and pollen-grains.

Now return to the willow shrub and watch another bee as it leaves the staminate catkins. It goes to the pistillate willow close by; in nectar these latter catkins are as rich as the staminate blossoms, and I have sometimes thought they were even richer, to make up for the lack of pollen, perhaps. The bee thrusts its tongue at once down

to the nectaries, and continues working thus for some time, all the while leaving pollen-grains here and there on the glutinous stigmas, and so the plant has its reward.

There is a marvelous correlation in the structural characters of these bees and their willow hosts. Each is perfectly adapted to supply the needs of the other — an instance of primitive coöperation, which, though it has doubtless taken æons of time to bring it about, seems now to us to have reached perfection. These little bees are the chief pollen-carriers for the willows, and to cater to their needs the plant has adapted itself in many ways. It furnishes an abundance of easily accessible pollen and nectar, early in spring when the bees need them, and before other blossoms appear to distract attention. To get the most advantage from the bees, it has developed the rough sticky projecting stigmas, so well fitted to catch pollen-grains from their bodies.

The bees also have done their part in developing structural peculiarities of service both to the willows and themselves. The distribution of the barbed hairs on their bodies is such that in working on a plant like the willow the most pollen-grains will become entangled, and be carried to the stigmas. Their tongues are short and broad, and their bodies



Andrena and Nest.

of a size well fitted to work between the individual flowers of the willow catkins. Were their tongues considerably longer and their bodies larger, they might reach the nectar without thrusting their heads down into the pussy, and thus would be much less effective as pollen-distributers.

Should you be able to watch one of these bees when, finally loaded with pollen and nectar, it leaves the willows, you would see it fly to some sandy bank in the vicinity and crawl down a little hole in the earth. At the bottom of this hole is an oval cell, and along the sides are other similar cells. In one of these the bee forms a round mass composed of honey and pollen mixed together, and later she deposits on top of the mass

a small whitish egg. In due season this egg hatches into a little footless grub, which feeds upon the ball of honey and pollen. After some weeks it has consumed all of the food and is a full-grown larva. It now changes to the pupa or chrysalis state, and later again changes into an adult bee.

This in brief is the life-history of these little bees. The dozens of species of Andrena and Halictus that hover over every New England willow shrub probably have slight individual variations in habits, but, so far as we know, in essentials their biographies are similar. The bees are gathering honey and pollen for the sustenance of generations yet unborn, thus furnishing a striking illustration of that foresight which, for want of a better name and to conceal our ignorance, we call instinct.

There are many other bees, besides those belonging to the two genera named above, that are abundant upon the willow pussies. In regions where hive-bees are kept, they are common visitors; and frequently a great bumblebee comes tumbling along, stopping here and there to plunder a pistillate catkin of its nectar, or to fill the large pollen-baskets on its hind legs with the golden powder of the staminate blossoms. The Glaucous Willow blooms too early for most of the bumblebees, which

are still sleeping in last year's nest or some other snug retreat. It is just as well, perhaps, for these bees are too large to do the most effective service in willow-pollination. They require too high wages in nectar and pollen for the return they give, to be profitable servants, at least in competition with the smaller bees.

A Bee-Fly.

Various other four-winged insects related to the bees are occasionally found upon the willow-blossoms: ichneumons and saw-flies are sometimes frequent. But none of these are so abundant as the two-winged relatives of the common house-fly, many species of which visit the catkins, either to suck the nectar or to feed on the pollen, or both. The bee-flies of the Bombylius tribe often hover over the blossoms, imbibing the nectar through their long tongues, and flying from plant to plant almost with the swiftness of a meteor. There are also many of the flesh-fly tribe, including the shining "blue-bottle," and various larger species. These flies no

A Flesh-Fly, magnified.

doubt are of considerable use as pollen-carriers, but they cannot compare in efficiency with the smaller bees.

Several species of beetles may almost always be found by an hour's watching of a blossoming willow shrub. Most of them seem to come to feed on the pollen; a few to lap up nectar. If the plant is not too far from a village, one is likely to find many specimens of a pretty little beetle, less than a quarter of an inch long, black in general color, but having transverse dashes of white along the sides of the back; along the middle is a stripe of tile red. This is the buffalo carpet-beetle, or "moth," as it frequently is incorrectly called, and is the adult stage of the too well-known hairy "worm" that so often carries consternation to the heart of the New England housekeeper. The beetles develop in the house, and when the windows are opened for the spring cleaning they discreetly hie themselves to the fields and woods, where they feed on the pollen of willows and other spring flowers, flying back to

Buffalo Carpet Beetle; three stages, magnified.

the houses later to deposit eggs for another brood of larvæ. So far as concerns the willow, these beetles are of doubtful utility: they rarely visit the pistillate blossoms, and consequently render little service as pollen-carriers for the food they receive. Some other small beetles, however, which are attracted by nectar, are useful pollenizers, though only to a limited extent.

Tarnished Plant-Bug, magnified.

A few species of small bugs are abroad sufficiently early in the season to visit the Glaucous Willow blooms. Much the commonest of these is the tarnished plant-bug — an omnivorous little creature, about one fifth of an inch long, varying much in color, but usually yellowish brown, or yellowish green, more or less mottled with a duskier shade. Each is provided with a sharply pointed beak, which is inserted into tender plant tissues. These bugs are slightly useful as pollen-carriers.

The early spring butterflies, especially the Antiopa and American tortoise-shell, may frequently be seen flying slowly over the willow bushes, occasionally lighting on the blossoms to suck up nectar. They are poorly adapted for willow-pollination,

The Antiopa Butterfly.

although no doubt they do some service as pollen-carriers in return for the nectar they receive.

These various flying insects may, in a general way, be included on the willow's list of bidden guests. But to wingless creatures such as ants, no welcome is extended. There is no probability that such an insect would succeed in carrying any of the pollen-grains from a staminate to a pistillate flower, except where the twigs of neighboring shrubs were interlocked. Ants may occasionally be seen trying

The Tortoise-Shell Butterfly.

to get the nectar, but the hairs between the individual flowers render the plundering difficult.

The willows illustrate a law which applies to nearly all insect-pollenized flowers in which the staminate and pistillate blossoms are separated, namely, that the staminate blossoms are more conspicuous than the pistillate ones. The advantage of this arrangement is obvious: the bees will be much more effective pollenizers if they go first to the flowers where they will be dusted with pollen to carry to the pistils, than if they were first attracted to the nectar of the pistillate blooms.

The willows are believed by botanists to be descended from the oldest flowering plants — in which the sexes were on different plants, and the pollen was transported by the wind.

An excellent idea of the different characteristics of a wind-pollenized plant, and even the simpler forms of those pollenized by insects, may be obtained by comparing the poplar and the willow. In the former the anthers are explosive, bursting open suddenly in such a way that the very light and abundant pollen is scattered considerably even before it is wafted by the wind. The willow anthers are not explosive, and the pollen is much heavier and less abundant. The stigmas of the poplar are

enormously developed in such a way as to have a large amount of smooth surface for the lodgment of any stray pollen-grains; in the willow the stigmas are very different, and obviously adapted to removing pollen from insects that come in contact with them. Other anemophilous plants have similar characteristics.

II

THE MAYFLOWER [1]

Every one of these English plants and weeds has a long and eventful story of its own. — *Grant Allen.*

No native plant has so endeared itself to the New England heart as the Mayflower.[2] For two centuries it has been to young and old the sweetest of Spring's harbingers when, pushing its delicate blossoms through the fallen leaves, it appeared beside the lingering snow. It has charmed those fortunate ones who have wandered over the hills to find it, and brought glad tidings to those compelled to stay at home. It also has constantly served to carry Cupid's message, — a custom which I like to fancy may have originated when, in the infancy of Plymouth, John Alden brought Pris-

[1] This sketch in substantially its present form was first published in *The Popular Science Monthly*, May, 1894, and is here reprinted with the permission of the Editor.

[2] Or Trailing Arbutus, *Epigæa repens*.

cilla Mullens bunches of Arbutus blossoms that spoke not only for themselves but also for the hand that plucked them.

But Epigæa is a plant of decided interest in itself, apart from its associations. It was not originally designed as an emissary of the goddess of love, and its beauty was primarily developed without reference to the æsthetic needs of the Pilgrims or their descendants. Long before the Mayflower

The Mayflower.

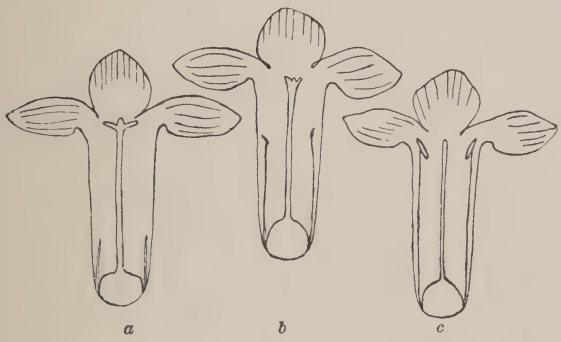
reached Plymouth or Columbus landed at San Salvador, — probably before the Indians arrived and possibly before the glaciers came down from the north, — the Arbutus blossomed with each returning season, and carried on the cycle of her existence as tranquilly as she does to-day. But her fra-

grance was by no means "wasted on the desert air," for she received then, as now, the tributes of a host of insect visitors that went about to do her unconscious bidding.

Although the Trailing Arbutus has been developing for so many centuries, it is still in a state of transition and appears to be looking toward a goal which probably will not be fully reached for centuries to come. Every one with the least knowledge of the vegetable world knows that the great majority of flowering plants have the stamens and pistil in the same blossom, although Nature generally devises some method of preventing self-pollination. Many species, however, bear the pistillate blossoms on one plant, or part of the plant, and the staminate blossoms on another plant or part of the plant, relying on insects or the wind to carry the pollen from the latter to the former. But occasionally one finds a plant whose flowers are neither wholly one nor the other, being in a transition stage between the two. The Mayflower is in this condition.

The examination of the structure of a dozen bunches of Arbutus blossoms reveals a great variation in the relative conditions and positions of the stamens and pistils. In some specimens the anthers are completely abortive; in others only

partially so; and in others in good condition, well filled with pollen-grains. Two types of stigmas are also present: in some blossoms the stigmas as a whole are broad and more or less flattened, — spread out, so to say, — projecting at right angles to the style, with the upper surface moist and glutinous. In others the stigmas are crowded into less space and project very little horizontally: they are drier



Variations of Mayflower.

and less glutinous, — evidently in a partially abortive condition. The perfect stigmas are usually associated with abortive anthers, and *vice versa*, so that many of the plants are already diœcious.

There are also great variations in the lengths of the styles and filaments of the pistils and stamens. In some flowers the stigmas are perfect and reach

the mouth of the corolla; no anthers and only the rudiments of filaments are present. The variations I found on Blueberry Hill, at Hanover, New Hampshire, may be summarized thus: —

1. Stigmas perfect, reaching the mouth of the corolla; no anthers and only the rudiments of filaments present (*a*).

2. Stigma perfect, reaching the mouth of the corolla; anthers present but abortive, reaching two thirds the way to the mouth of the corolla (*b*).

3. Stigmas perfect, reaching half way to the mouth of the corolla; anthers abortive or absent, not reaching the stigmas.

4. Stigmas imperfect; anthers perfect; both reaching the mouth of the corolla.

5. Stigmas imperfect; anthers perfect; both reaching two thirds of the way from the base to the mouth of the corolla.

6. Stigmas imperfect, reaching slightly beyond the mouth of the corolla; anthers perfect, reaching to the mouth (*c*).

The relative proportions of the different forms seem to vary with the locality. The majority of specimens I have studied belonged either in the first or fourth categories. The Mayflower at Hanover is evidently tending toward a more perfect

dicœcism. When it finishes the elimination of the filaments, as it has the anthers of the stamens, in many of the pistillate blossoms, and gets rid of the superfluous pistils of the staminate blossoms, it will accomplish its purposes of reproduction with less waste than at present.

A plant in the condition of this Arbutus may be said to be in a certain sense at a "parting of the ways." To attain the end of cross-fertilization, — the bringing of the pollen from the stamens of one plant to the pistil of another, — two methods appear to be open to it. It may, and in the case of many of the Blueberry Hill specimens evidently has, become more perfectly dicœcious, by aborting the stamens on some plants and the pistils on others; or it might become dimorphous by developing perfect sexual organs and having them at different heights, — that is, have the stamens on one plant reach the mouth of the corolla, and the pistil reach only half way to the mouth, while in another having the pistil long and the stamens short. The tendency toward dimorphism or trimorphism is shown by the varying lengths of the styles and filaments.

An interesting point in connection with the anomalous condition of the Trailing Arbutus is

the fact that in many localities where it blossoms in abundance it sets no fruit, and appears to depend entirely on its vegetative growth for multiplication. This peculiarity of the plant has been described at some length by Professors Gray and Goodale, as well as by several other noted botanists.

The blossoms of the common Asparagus of our gardens show that they are in a transition stage, somewhat similar to that of the Arbutus. The staminate flowers have rudimentary pistils, and the pistillate ones rudimentary stamens. Sometimes a blossom is found which has both sets of organs well developed, — a reversion to an earlier condition of the plant.

The Partridge Berry,[1] a plant which has to contend with much the same external conditions as the Mayflower, — living in similar situations and remaining close to the ground, — has adopted dimorphism as its method of securing cross-fertilization. The beautiful white blossoms of this species open early in summer. The stamens of some individuals are exserted, with the stigmas below the mouth of the corolla, while in others these conditions are reversed. Another common example of a low-growing plant with dimorphous sexual organs

[1] *Mitchella repens.*

is that of the familiar Bluets.[1] The dainty blossoms of this species are small individually, but they are often so abundant on New England hillsides as

Long-Styled and Short-Styled Forms of Houstonia.

to cover them like a light fall of snow. A sectional view of the two forms of flowers is shown above: *a* represents the long-styled form with the stamens in the lower portion of the corolla tube and the stigma exserted, while in *b* the stamens are near the mouth of the corolla and the stigma is below. These blossoms are mainly pollenized by small bees and butterflies, one of the commonest New England visitors being the Meadow Fritillary.[2] When an insect sucks the nectar from the base of the corolla of a short-styled blossom, it will get at a certain place on its tongue some of the pollen

[1] *Houstonia cærulea.* [2] *Brenthis bellona.*

from the anthers. If next it visits a long-styled blossom, it will be likely to brush some of this pollen on to the exserted stigma, while a point near the tongue will receive a fresh supply of pollen-grains. If now it again visits a short-styled blossom, this last received pollen will be at the right height to be deposited on the included stigma. Consequently cross-fertilization will almost certainly occur.

To return to the Mayflower, it is evident from the structural conditions described above that the production of seed will require the carrying of the pollen from the staminate to the pistillate blossoms.

The Meadow Fritillary.

The insects and the wind are the only messengers available for this purpose. The structure of the plant shows that under any ordinary conditions the wind would not serve the purpose, so that the insects only are left. It might at first seem that so early in spring as the Arbutus blossoms there

would be few insects abroad, — not sufficient for the purpose. But centuries of experience have taught the plant that the nectar hidden beneath her dainty petals will attract many visitors. In New England the beautiful orange-banded bumblebee[1] is the most abundant visitor. Dozens of the large females which have passed the winter in some sheltered nook are generally present, gathering the nectar concealed in the bottom of the corolla cups. Each bee stops but a few seconds at a flower. It visits on an average three or four bunches of blossoms a minute. After alighting either on a flower or on the leaves or ground between, the bee crawls from blossom to blossom, poking its nose, so to speak, down under the leaves that none shall be missed, often visiting a dozen heads before taking to wings again. When the wind blows hard — a frequent occurrence on such hilltops — Madame Bombus (these early spring forms are all females, the so-called queens) flies still

The Orange-Banded Bumblebee.

[1] *Bombus bifarius.*

more rarely, crawling long distances instead. The tongue of this bee is two fifths of an inch long; its tip readily reaches the bottom of the corolla, being thrust quickly down between the hairs. There are generally several blossoms in a single head; and as a rule each is plundered before the visitor departs. I saw one bee visit six heads in ninety seconds, and another seven heads in the same length of time. On the supposition that there were five blossoms per head, the first bee was plundering twenty flowers a minute. Supposing that half of each hour was spent between the plants or going to the nest, the bee at this rate would visit six hundred blossoms an hour, or six thousand in a ten-hour day, if she should work so long. On the five acres of hilltop where my observations were made, I judged that at least one hundred of these bees were at work each day. Supposing that they all work at the rate above suggested, the Mayflowers would receive six hundred thousand daily visits. Probably many of the blossoms are visited more than once each day, but the chances are certainly very good that each blossom will be visited at least once during the two weeks of its existence.

Although the orange-banded Bombus is much the most abundant visitor, at least two other related

species are often seen. The commoner of these is a large and handsome Bombus,[1] black except for two broad yellow bands, — one on the thorax and one on the abdomen. The other, which is seldom seen, is called by entomologists *Bombus consimilis :* the thorax and front half of the abdomen are yellow, with the hinder portion of the abdomen black.

Hind Leg of Bombus bifarius.

By watching any one of these bees closely, one can see it stop every few minutes to brush the pollen-grains off from its tongue and head, but no attempt appears to be made to collect them in the beautifully developed pollen-baskets on the legs. These bees evidently visit the Arbutus for the nectar it furnishes.

[1] *B. terricola.*

While the bumblebees are much the most numerous and important of the Mayflower's invited guests, a few other insects are found among the visitors. A rather small two-winged fly, with a hairy yellow body and black-banded wings, often flashes, meteor-like, from blossom to blossom. This is the handsome bee-fly of the genus Bombylius,[1] one of the earliest spring insects. It has a very long tongue which readily reaches the bottom of the Mayflower corollas. I saw one of these flies stop twenty seconds at a single flower; it thrust its tongue down on one side of the pistil, then drew it out and pushed it down in another place, repeating the operation four times.

The Bee-Fly.

During the warmest portions of the brightest days the beautiful clear-winged Sesia moths appear. They are sometimes called humming-bird moths because of their resemblance when flying to a humming-

The Sesia Moth.

[1] *B. fratellus.*

bird, though the smaller of our species,[1] the one I find visiting the Arbutus, is more suggestive of a bumblebee. They have long tongues curled up when not in use, through which they suck the nectar of flowers. Unlike most moths which fly at dusk, the Sesias are abroad in the brightest sunshine.

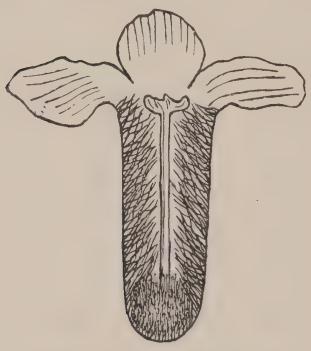
Occasionally one of the early spring butterflies — especially the American tortoise-shell[2] and the Antiopa[3] — may be seen hovering over the blossoms.

Wingless Ants.

The insect visitors so far considered are all useful to the Mayflower. They pass rapidly from head to head and from plant to plant, carrying the pollen from staminate to pistillate blossoms and thus bringing about the fertilization of the embryos and the development of seeds. But the surface of the rocky hillsides where Epigæa is most thoroughly at home swarms with ants of various species, — wingless creatures that dearly love the nectar of flowers. These insects wander everywhere in search of food, and

[1] *Hemaris diffinis.* [2] *Aglais milberti.* [3] *Vanessa antiopa.*

may often be seen trying to get at the nectar in the bottom of the Arbutus blossoms. Could they succeed, little would be left for other visitors: consequently the ants would not only be of practically no value as pollen-carriers, — for rarely would one chance to wander from a staminate to a pistillate blossom, — but they would also prevent the visits of the useful bees and flies. The plant, however, has fenced out these and other similar unbidden guests by an elaborate *chevaux de frise*, composed of hairs projecting slightly upward from the inner surface of the corolla, and the outer surface of the ovary and style. It is easy for a bee, moth, or fly to push its slender tongue down through these hairs to the base of the flower-cup, but an ant finds it difficult to force its body down till its mouth is at the bottom.



Sectional View of Mayflower.

III

THE SPRING BEAUTY

Has Nature colored this ring for the express purpose of showing insects the way to the honey receptacle ? I examined with regard to this hypothesis other flowers, and found that the majority supported it. For I saw that those flowers whose corolla as commonly happens is colored differently in one place than in the rest, always have these spots, figures, lines, or dots of special color at the place where the entrance to the honey is found. — *Sprengel.*

Mr. Julian Hawthorne recently expressed a very general misconception in remarking that "Botany is a sequel of murder and a chronicle of the dead." While this once was largely true, in a broad and general sense, it is no longer so. During the last half-century the ideals of botany have been revolutionized, but a knowledge of the fact is just beginning to be borne in upon the mind of the non-botanical public. Even to-day the word botanist is likely to bring before one the vision of an erratic individual with an overgrown fruit-can hanging by his side, wandering

over hill and dale in search of weeds and herbs; or of a musty closet filled with mustier specimens, and a still more musty man poring greedily over them. But such visions are largely a heritage from the past. The botanist of to-day is as likely to collect his specimens in a pill-box or on the point of a needle as in a vasculum. His collecting fields are as likely to be the test-tubes of the laboratory, the aquaria of the class-room, or the benches of the conservatory, as the outdoor world. Instead of being a recluse, he himself is likely to be a man among men, actively interested in the world's affairs. Botany to him, rather than a sequel of murder, is oftener a witness of new births, and his ancient prototype's chronicle of the dead becomes with him a chronicle of life.

The reason of this radical change is not far to seek. Since man has learned that the universal brotherhood of life includes himself as the highest link in the chain of organic creation, his interest in all things that live and move and have a being has greatly increased. The movements of the monad now appeal to him in a way that was impossible under the old conceptions. He sees in each of the millions of living forms with which the earth is teeming the action of many of the laws which are

operating in himself; and has learned that to a great extent his welfare is dependent on these seemingly insignificant relations; that in ways undreamed of a century ago they affect human progress. These considerations have made the botanist a biologist, and have led intelligent people to hold him in higher esteem than they could have held the eighteenth-century herbalist.

To a great extent we are indebted to Darwin for this enlargement of vision. By shattering the conception of the independent creation of species, he breathed the breath of life into botany and zoölogy and wedded them into biology. Thenceforth the interest of the botanist was with the living rather than the dead. Dead plants could tell no tales equaling in interest those of the living, and even the tales of the dead were transformed into a new significance. The master-naturalist, watching for weeks the movements of tendrils, or patiently studying an opening orchid bloom, revealed the method of the new era, — a method later defined by Drummond: "To watch uninterruptedly the same few yards of universe unfold its complex history; to behold the hourly resurrection of new living things, and miss no change or circumstance, even of its minuter parts; to look at all, especially the

things you have seen before a hundred times, to do all with patience and reverence, — this is the only way to study nature."

But even in the pre-Darwinian days botanists were not all musty herbalists, delving in the dry bones of a dead science. Something over a century ago there lived in Spandau, a village near Berlin, a country rector who was led by the botanist Heim to study plants. Nature proving to him of greater interest than eighteenth-century theology, his clerical duties were so neglected that he lost his position. Then he went to Berlin. Establishing himself in bachelor quarters, he earned the little money he needed by teaching botany or languages, — his pupils usually finding him pursuing his favorite studies, clothed "in an old bedgown, with a night-cap and a long pipe, the room filled with tobacco smoke."

This man was Christian Konrad Sprengel, who a century ago published a work on the pollination of flowers which opened to the world one of the most fascinating pages of Nature's greater book. Sprengel's volume was either unread or ridiculed for nearly fifty years, when Darwin saw the truth contained in it. Applying himself to original observations on the subject, the latter naturalist led

botanists into a new and charming field of work, — that of the relations of flowers to their insect visitors. To this field numbers of workers have since taken themselves, and have been amply repaid by

The Spring Beauty.

the discovery of some of the most marvelous interrelations of the plant and animal world.

To see something of these marvels one need not go far afield. An attentive study of the first wayside blossom will probably reveal them. The com-

mon Spring Beauty, which so often carpets the fields and woods with tints of delicate pink and green, seems as simple a flower as one well could find, yet it is of decided biological interest. For many centuries it has been perfecting its relations with the insect world, excluding undesirable visitors while extending a hearty welcome to those proving themselves useful.

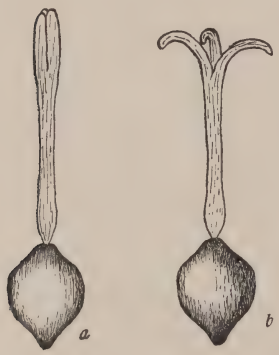
Like the great majority of flowering plants, the Spring Beauty has the two sets of essential organs — the stamens and pistils — crowded together in one blossom. The pistil occupies the central position: it consists of a lower part, the ovary, which contains the embryo seeds; a middle part, the style, which connects the ovary with the stigmas at the top. The stamens consist of a slender filament, attached below, bearing on the tip a pollen-bag or anther in which the yellow pollen-grains are developed. For the fertilization of the ovules it is necessary that these pollen-grains become attached to the stigma, when they send out slender tubes, which penetrate downward through the style and fertilize the embryo seeds in the ovary.

It was formerly supposed that all that was involved in this process of fertilization was that some pollen-grains from a stamen should get upon

the stigma beside it in the same flower. Consequently there seemed to be no reason for the existence of delightful odors or brightly-colored petals and sepals except to please the senses of man, — "the most egotistic of animals," — who has always been glad to emphasize any indication that Nature is ministering unto him. This view led to the poet's assumption that blossoms blushing unseen were but wasting their beauty and fragrance on the desert air. Sprengel and his followers, however, have taught us that a large proportion of the flowering plants have adopted various methods of preventing self-pollination and of insuring cross-pollination or the bringing of pollen from another flower. In the light of their discoveries it appears that colors and odors have been primarily developed without reference to the æsthetic senses of man, but for the purpose of attracting various insects — especially butterflies, bees, and flies — and using them as pollen-carriers.

The pollination of the Spring Beauty may best be observed on a sunny day in one of the open groves where this plant especially loves to dwell. Lie down beside a clump of blossoms and look at the nearest ones closely. You notice that each of the five petals has on its inner surface three to

seven branching stripes of a delicate rose-pink color. These meet near the base of the petal, usually in a blotch of lemon — or gamboge — yellow. They are the "pathfinders," which point the way to the nectar at the bottom of the corolla cup. If you are looking at a newly-opened blossom you will see that the stamens surround the pistil in the middle of the flower. Before deciding that this must result in self-pollination, push the stamens aside and examine the stigma. It resembles *a* in the figure herewith. No part of the glutinous surface to which the pollen adheres is exposed. Now look at another flower that has been open a day or two longer. The filaments in this blossom have curved outward so that the empty anthers hang over the petals; the stigma, instead of being a cylinder, has split into three parts, with the glutinous pollen-catching surface of each uppermost (*b*). To prevent self-pollination the plant has so arranged matters that the stamens develop first and the stigmas afterwards.



Pistil of Spring Beauty.

But how is cross-pollination induced? Watch

and see. Yonder comes a great golden-banded bumblebee, lumbering through the air. She stops now and then at a Beauty blossom, sucking up the nectar. At the same time more or less pollen is brushed from the stamens of the blossoms in the first stage and carried to the pistils of those in the second. Various small hairy dark-colored bees are much more abundant than the bumblebees. They are after both nectar and pollen, and are very useful to the plant. So also are a great variety of two-winged flies that come for nectar or pollen or both. One of the most interesting of the latter is the little brown-bodied Bombylius, which flies very swiftly and hovers over the blossoms like a humming-bird. Many species of butterflies also visit the flowers and are slightly useful as pollen-carriers.

The Dogtooth Violet.

There are some insects for which the Spring

Beauty has no use. The wingless ants are perhaps the most important of these. The plant prevents their visits by means of the delicate bending stem with the blossom at the tip. I once saw a small black ant crawl up two stalks and vainly attempt to get at the nectar; then it tried a third one

A Brood of Woodcock.

which happened to have a flower from another plant resting against it, the nectar of which the ant reached. This was an accident due to the crowding together of the plants, showing that the "ganging agley" of the best devised plans is not confined to mice and men. Many other flowers have adopted this slender-stem method of prevent-

ing the visits of crawling insects. To this cause, in part at least, we may ascribe the drooping modesty of the Dogtooth Violet and the delicate setting of a large proportion of our spring and summer blossoms.

The Spring Beauty is by no means the only object of interest in the May woods. Among the clumps of flowers you will occasionally stumble upon a brood of young grouse or woodcock, — charming little creatures that attempt to pass themselves off as inanimate bits of the surrounding landscape. Last spring I came across two broods of woodcock. I found two of one and three of the other. The latter very obligingly stood upon a stump in various characteristic attitudes while their photographs were taken.

The Spring Beauty has, to use the expression of an English naturalist, "laid itself out" to attract a great variety of insect visitors. Its blossoms are small and open, so that the nectar is easily accessible to almost any flying insect; and its colors are such as appeal to widely separated species.

There can be no doubt that certain insects have decided color preferences. Sir John Lubbock's experiments on bees — in which it was found that these insects prefer blue to other colors — confirm

the impression one may gain from a field study of flowers and insects. As a rule the flowers especially adapted to pollination by bumblebees are not white or yellow, but are red or blue or pink. White and yellow attract insects less perfectly adapted to flower visits. They are the democratic colors. Blossoms of these colors — except those pollinated by night-flying moths — generally have nectar which is easily accessible and are visited by a great variety of insects. Our common buttercups, for example, the simple structure of which is shown in the accompanying sectional sketch, appeal to a large circle of visitors. In Europe Müller found the three closely related species — *Ranunculus acris*, *R. repens*, *R. bulbosus* — to be visited indiscriminately by the same insects, and records sixty-two different species which he found upon them. Twenty-three species belonged to the order of two-winged flies; eleven belonged to the beetle order and represented eight different families; there were twenty-four species of Hymenoptera — the order of bees and wasps — and four kinds of

Sectional View of Buttercup.

butterflies. The most abundant visitors were the small bees of the genus Halictus and its allies,

The Marsh Marigold.

already referred to as willow visitors; and the brilliant flies of the family Syrphidæ. These flies are among the handsomest of insects. Much of

their color is believed by many naturalists to be the result of sexual selection. Yellow is the prevailing color-marking on their bodies, and yellow flowers of simple structure are very sure to receive their visits. Under natural conditions they appear to be the chief pollinators of the beautiful golden-yellow blossoms of the Marsh Marigold,[1] the color of which is so similar to that of the buttercups.

Conspicuousness is an important element of success in attracting insect visitors. An abundance of nectar in a blossom only visible for a very short distance would be less advantageous to a plant than less nectar but greater showiness. The methods flowers have adopted to attract attention are infinite; any morning walk will show dozens of them. Large blossoms generally stand alone or have but few immediate associates: small blossoms are in companies. The family Umbelliferæ most strikingly illustrates the latter statement. In these plants large numbers — often hundreds — of minute flowers are crowded together to form heads which become very conspicuous. The members of this family, which includes the Wild Carrot, the various parsnips, the Water Hemlock, and the Caraway, Fennel, Lovage, Carrot, Parsley, and many other

[1] *Caltha palustris.*

The Wild Carrot.

plants, are characterized by having the small flowers in umbels, with the honey freely exposed or nearly so, so that it is easily accessible to short-lipped insects. The common Wild Carrot[1] is a good example of the group. This is one of those European plants which have been introduced into America, where because of their great advantages in the struggle for life they have become noxious weeds, crowding out the plants which man desires to grow. Late in summer throughout a large portion of New England the white blossoms of this Carrot enshroud the hillsides as with a snowy garment. It has gradually spread westward and will no doubt prove a troublesome pest over most of the United States.

The members of the elder family have adopted the same method as the Umbelliferæ in grouping together large masses of white blossoms to attract insects.

Few people realize the extent to which man is indebted to insects for his own subsistence. A large proportion of the fruits and vegetables upon our tables daily is the direct result of the pollinating efforts of the bees and their allies. One of the most common causes of the whole or partial failure

[1] *Daucus carota.*

of the crops of orchard fruits is the inability of the bees to do their work on account of rainy weather. This was strikingly illustrated during the season of 1894. In southern New Hampshire the weather during the blossoming period of pears, apples, and other orchard fruits was very dry, so that for at least two weeks the bees had ample opportunity to work. The result was an extraordinary crop, nearly all the trees setting a large proportion of their blossoms. In southern New Jersey, during the same season, "when the trees and vines were in bloom there were frequent and heavy rains." The result was a marked failure of the crops, due very largely to the prevention of pollen distribution.

Mass of Elder Bloom.

IV

THE PURPLE TRILLIUM

The dependence of entomophilous flowers on guests so infinitely various in habits, tastes, and numbers, in their food and in the means of obtaining it, must have rendered possible not one, but countless paths to perfection, paths leading not always forward but sometimes backwards; and only in such a way could the infinite variety of existing flowers have come into existence. — *Hermann Müller.*

While the Spring Beauty, the members of the parsley family, and many other plants have called to their assistance a great variety of insects, some flowers have found it profitable to cater to the tastes of a more limited constituency, sometimes even going outside the circle to which floral visitors are generally confined. A striking illustration of this is seen in the Purple Trillium,[1] abundant in damp woods throughout New England. This flower is of a dull reddish purple color; it secretes no nectar and has a disagreeable carrion-like odor. The pistil is of the shape represented on page 55. In the first flowering

[1] *T. erectum.*

stage the upper portion remains united, as seen at *a*, but later the tip splits into three divisions which curve outward as in *b*. The stigmatic surface lies

The Purple Trillium.

along the inner edge of each of these divisions. The anthers of the stamens are of good size and yield an abundant supply of pollen, which is ready for dispersal before the stigmatic lobes of the pistil open.

For several years I was puzzled over the pollination of this Trillium. It presents no attractions to bees or butterflies; they prefer prettier colors and sweeter odors. I saw no insects visiting it, although it obviously is adapted to cross-pollination. One day last summer I sat down among a group of these blossoms on the side of a New Hampshire hill, resolved to surprise their secret if patient watching would do so. I soon noticed a number of flies buzzing around. They had evidently been frightened off by my approach, and were coming back. There were two or three species of them. They were constantly alighting on the leaves, from which they would crawl up the stem to the flower and nibble at the pollen. Sometimes when the blossom of one plant rested upon the leaf of another the flies would reach it without crawling up the stem. In wandering over the blossoms they undoubtedly effected cross-fertilization.

a *b*

Pistil of Purple Trillium, magnified.

Flesh-Fly Visitor to Trillium, magnified.

These flies were all of the group of flesh-flies or carrion-flies. All the specimens I caught were the common green fly, — the species known to entomologists as *Lucilia carnicina*.

This discovery of the mode of pollination of the Purple Trillium suggested some interesting reflections. I had read — and wondered in the reading — about the Rafflesia of the oriental islands, — the blossom of which is said to resemble in color and odor raw beefsteak of an uncertain age, and to delude unwary flies into depositing their eggs upon it, while performing for the plant the pollen-carrying function. A feeling of doubt had always lingered about this Rafflesia story in my mind, — perhaps because I first read it in one of Grant Allen's charming books, which the botanists declare to be "taking but not sound." But here in staid New England, under the orthodox shadow of Dartmouth's classic halls, was confirmative evidence concerning this Arabian Nights story from the Orient. Here was a plant which had adopted the same tactics to attract the occidental cousins of Rafflesia's oriental guests. The color and odor were now explained: the plant has adopted them to beguile flesh-flies, which it furnishes with a free lunch of pollen. I wondered if the taste of the pollen was

in keeping with the smell, but I did not attempt to determine the matter experimentally.

The leaves of this Trillium are broad and usually horizontal. They form a good landing-place for the flies. The blossom stems run up about two inches above the whorl of leaves, but the stems are nearly always curved in such a way that a fly can crawl up to the blossom; when it reaches it there is nothing to prevent crawling over to the front of the flower. Evidently this plant has not found it necessary to adopt methods of excluding unwelcome guests. The absence of the usual attractions has been sufficient.

Several years ago I was botanizing in Northern Ohio along the beautiful shores of Lake Erie. *Trillium erectum* was there abundant, but the uninitiated would scarcely recognize it as the same plant that we have in New England. The blossoms are pure white, while ours are purple. Gray's Manual says the flowers of this species are "brown-purple or often white or greenish or pinkish," — a decided range of variation for such a flower. Why should the Ohio blossoms differ so markedly from ours? Have the flies been so scarce that the plant has reverted to the white, from which no doubt it originally started? Or have they been

so busily engaged about the populous homes of the Buckeye State that they have not learned that this woodsy beauty is wooing them, so that their neglect has led to self-pollination and consequent reversion? I suspect that in some sense this is true.

This variation may serve to illustrate a point that should be clearly understood. In these pages I have described blossoms as adapting themselves to varying conditions and varying visitors. But of course there can be no conscious adaptation on the part of the plant. If man — the greatest of created beings — is unable by taking thought to add one cubit to his stature, certainly a plant — without taking thought — cannot add a line to the length of its pistil. The leopard cannot change his spots nor can the lily change her tints. But what cannot be done by one plant in one generation can be done by many plants in a long series of generations.

No fact concerning the vegetable kingdom is better established than that all parts of all plants constantly vary. Roots, stems, leaves, and blossoms all illustrate this law. The range of variation is infinite: it includes color, odor, shape, and size, the time of sprouting and growing, as well as of blossoming and fruiting. We know a little,

but not much of the cause of variation. It is seldom that all the inorganic conditions — soil, moisture, heat, sunshine — under which two plants grow are precisely alike, and varying conditions produce varying results. The factors of heredity are also believed to be potent causes of individual changes.

But, however caused, the fact of variation is indisputable. So also is the fact that plants produce vastly more seeds than can develop. This results in a constant struggle for existence between different species and between the individuals of the same species. Any variation by means of which a given plant gains an advantage over its fellows will be likely to lead to its maturing and fruiting, while the less favored ones are crowded out before fruitage. Consequently variations which favor the species in its environment will be transmitted from generation to generation, — constantly tending to more perfect adaptation to surroundings, — while the unfavorable variations will be eliminated. Nature is conducting a vast experiment station in which her creatures are acting and reacting on each other, mercilessly eliminating those which do not meet the requirements of life, but encouraging those which do.

It is in this sense that we are able to speak of plants adapting themselves to their surroundings. The adaptation results chiefly from the working of the principle of natural selection acting through countless generations.

V

THE JACK-IN-THE-PULPIT

The more I study Nature the more I become impressed with ever-increasing force that the contrivances and beautiful adaptations slowly acquired through each part, occasionally varying in a slight degree but in many ways, with the preservation of those variations which were beneficial to the organism under complex and ever-varying conditions of life, transcend in an incomparable manner the contrivances and adaptations which the most fertile imagination of man could invent. — *Darwin.*

While the Purple Trillium caters to the tastes of a special group of flies for which most flowers have little use, the Jack-in-the-Pulpit or Indian Turnip[1] has formed an alliance with a still more obscure family, — one which very few other flowers regard as of possible usefulness. The structure of this blossom is peculiar. It consists of a large spathe, the lower part of which forms a cup over which the upper part arches as shown in the accompanying illustration. On the inside there projects upward from the

[1] *Arisæma triphyllum.*

base of the cup the spadix, — an organ of the shape shown in the figure on page 63. It bears on its basal part, either the stamens (*a*) or the pistils (*b*),

The Jack-in-the-Pulpit.

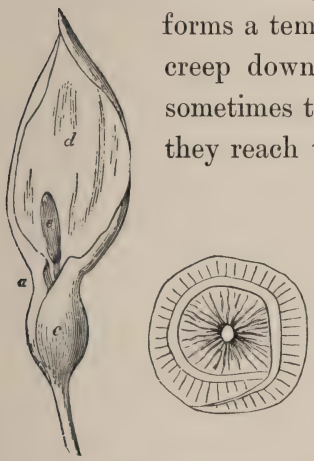
or sometimes some of both. A little above the stamens or pistils, the spadix abruptly enlarges, and thence runs as a good-sized cylinder some distance out of the cup. The exposed portion, as well as the inner side of the overhanging tip of the spathe,

and more or less of the rest of the spathe, is of a dark red or purplish color, — the tint varying considerably in different plants.

Spadix of Jack-in-the-Pulpit.

a, staminate; *b*, pistillate.

Many years ago I read an account of the mechanism by means of which the European cousin of our Jack-in-the-Pulpit gets itself fertilized. In this plant "the upper part of the spathe (*d* of the figure below) serves as a wide conspicuous entrance, guiding small Diptera (*Psychoda*) into the lower chamber (*c*), which forms a temporary prison. The insects creep down the dark red spadix (*e*) or sometimes the sides of the spathe until they reach the upper part of the chamber (at the level of *a*). At this point several rows of hairs (metamorphosed stamens) radiate outwards, pointing slightly downwards, from the spadix, and form a palisade which does not prevent the small



European Spotted Arum.

visitors from creeping down into the chamber (*c*), but afterwards prevents them escaping when they try to fly towards the light. Even when they try to escape by crawling up the spadix, the sharp downturned points bar their way.

"In the first stage of flowering the stigmas only, which are borne by the base of the spadix, are mature; a foul ammoniacal smell attracts the small flies into the prison, where they cross-fertilize the stigmas if they have come from other plants. In the second stage the stigmatic papillæ wither, and a drop of honey appears in the middle of each stigma to reward the little visitors for their pains. In the third stage the anthers open, and the greater part of their pollen falls upon the floor of the chamber; the insects dust themselves over and over with it, and finally, when the palisade of hairs withers in the fourth period, they pass out and enter another flower in its first stage."[1]

At various times I had pulled the flowers of our Indian Turnip to pieces, finding that small gnats and similar flies very frequently get in the cup, but I was puzzled as to how they escaped. In order to learn whether the special examination of many flowers would add to my knowledge of the

[1] Müller.

matter, I started from Hanover one morning last May (the 27th), up the Connecticut River for a woodland where the plant grows abundantly. I was always glad of an errand north on the east side of the Connecticut, for not quite two miles up the river there is one of the most beautiful views of this famous valley. Passing along the level road, you suddenly come to a descent, before taking which you should pause to view the scene: on the left runs the glinting river bordered on the west by the Vermont hills, and on the east by the terraced valley which lies before you; on the right hills rise above hills, culminating in the group to which Smart's mountain belongs; and in the far north you get a glimpse of Moosilauke and her stately sisters. This scene is always beautiful, but in early summer, when grass and trees are clad in richest green, and in autumn, when the landscape seems a living flame, its glory is transcendent.

When I arrived at the woodland I found the "Jacks" in full bloom, and examined a large number of them. In most of the chambers there were small two-winged gnats. Some were alive and buzzing, but many were dead. They could easily get down between the spadix and spathe, but when they attempted to fly out they were blocked by the

projection on the spadix. The only other place of egress was a small opening on the side of the flower near the bottom where the borders of the spathe overlap. This opening varies in size in different plants, and apparently at different ages of the same plant. I think that in many cases it opens wider as the plant grows older. At any rate this is the case with the walls of the spathe, as specimens blossoming in the laboratory showed. When the walls of the spathe thus open wider, the space between the wall and the spadix becomes greater, so that there is better opportunity for imprisoned gnats to escape upward. Apparently the gnats must get out either through this upper exit or the opening below; and those which are not small enough or clever enough, or do not live long enough, perish in the chamber.

Through the kindness of Professor J. M. Aldrich — a specialist in the Diptera — I learned that the flies in the spathes belonged to the family of fungus gnats, especially to the genus Mycetophila (*M. sericea* being the prevailing species). These flies abound in the damp woods where the Indian Turnip is most at home: they are minute, active, and more or less mosquito-like in appearance. The larvæ are small, somewhat cylindrical, legless worms

or maggots, living in the larger fungi — the toadstools, mushrooms, and their allies — or under the bark of decaying logs or other vegetable refuse.

These fungus gnats are evidently attracted to the Jack-in-the-Pulpit blossoms. Probably the color has some influence, and possibly they think the chamber a snug retreat from storms. But in whatever way they are enticed, many of them find it a chamber of death. The adaptation of plant and visitor is not yet so perfected that the interests of both are perfectly subserved. In fact, the frequency with which one finds both staminate and pistillate organs in one flower seems to indicate that dicœcism in this species is a comparatively recent development, and that this plant — like the Mayflower — is still in a state of transition.

Early in spring, generally before the snow has wholly gone, one may find in swampy places the peculiar hooded flowers of the Skunk Cabbage.[1] To the uninitiated it would seem that this earliest of flowers — repulsive both in color and odor — would fail to attract insects. But if you study the blossoms on a sunny day you will find in a large proportion of them small, active flies which are serving as pollen-distributers. Those which I have

[1] *Symplocarpus fœtidus.*

taken in the flowers mostly belonged to the genus Phora, but some were of the genus Limosina. These small flies breed in marshy places, where they pass the winter under fallen leaves. In spring when the snow is gone they become active, and are attracted to the Skunk Cabbage by its odor and color.

Along the borders of the woods where the Purple Trillium and the Indian Turnip love to dwell, there may often be found a dainty little blossom, modestly looking upward from between the fallen leaves. If you brush some of the latter aside you will find a slender golden-yellow root-stalk connecting blossom with blossom. This plant is the Gold-thread,[1] and, though seemingly so insignificant, it possesses an extraordinary biological interest. If you examine the flower you will find the sepals white and petal-like ; the stamens small and numerous ; the pistils with large curved stigmatic surfaces. But the petals will puzzle you. Between and in front of each pair of sepals there rises a peculiar column which gradually enlarges from below upward, and finally terminates in a cup-like disk, yellow with a white centre. The surface of this cup is covered with a transparent, sticky, semi-

[1] *Coptis trifolia.*

liquid substance. These remarkable columns are petals transformed into nectaries.

No New England blossom illustrates more strikingly the adaptation of a plant to its environment than this Goldthread. One would think that surely this inconspicuous little flower, living so close to the ground in damp shady woods, where bees and butterflies are seldom seen, must be habitually self-pollenized. But Coptis has long since learned the significance of small things, and is as perfectly adapted to its surroundings as is the most complicated orchid of the tropical forest. The next time you come to one of these flowers, get down on your knees to it, and if you are patient you will see a tiny black speck among the stamens. Look through your lens and you will find a little two-winged fly — one of the fungus gnats — with its mouth in the nectar-cup feeding on the nectar. See it leave this particular nectary and wander over the stamens and pistils till another is reached, and after feeding from that see it fly to a neighboring blossom to glean from the petals there. In so doing it carries on the legs and body the pollen from the first flower and leaves it on the stigmas of the second.

But Coptis does not rely on the fungus gnats

alone for the pollen-carrying function. On some of the flowers you will find a small, elongated beetle, which feeds both on nectar and pollen, and is a very effective agent in cross-pollination. Several of these beetles which I observed first fed upon the pollen from the anthers, and then washed it down with the liquid in the nectar-cups. I sent specimens of these insects to Dr. C. V. Riley for determination, and learned that they belong to the species known to science as *Anaspis flavipennis*, though I doubt not that the beetle by any other name would prove as useful to the plant. When one becomes dazed by the hazy mass of entomological synonymy it is a comfort to turn to the study of biological relations, and to realize that while very few of our insects have been burdened with names for a single century, they have all been developing for thousands of years toward a more perfect adaptation to surroundings. Both the Goldthread and the beetle have perfected their relations without reference to the Latin binomials which man was to apply to them.

This beetle belongs to the family Mordellidæ, the larvæ of many species of which are fungus-feeders, while the adults are flower visitors. The damp woods where Coptis dwells form just the

situations in which the fleshy fungi readily develop, so that there is likely to be a good supply of the fungus gnats and fungus beetles always in the vicinity. The entire flower is constructed with reference to their visits: the showy sepals attract their attention; the abnormal petals furnish them food; the many small stamens with white anthers and white pollen furnish a surface to walk upon, and a foreground in which the yellow nectar-cups are distinctly visible; the long-spreading recurved stigmas cover so large a portion of the blossom that it would be difficult even for one of the tiny visitors to take many steps without coming in contact with one of them. Surely the Goldthread is worthy of more than passing notice.

VI

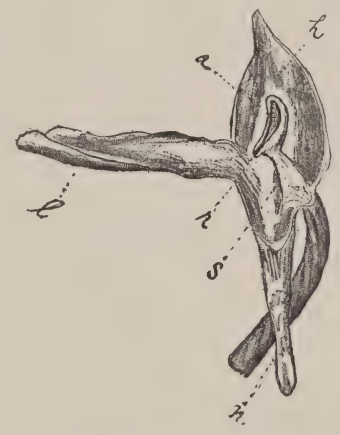
THE SHOWY ORCHIS

There is not a hair or a line, not a spot or a color, for which there is not a reason, — which has not a purpose or a meaning in the economy of Nature. — *Lubbock.*

The orchids have long been famous on account of their relations to insect visitors. The marvelous ways in which they have adapted themselves to the insects available for pollen-distribution were clearly pointed out in Darwin's classic "Fertilization of Orchids," and have repeatedly been described since. From this point of view the Showy Orchis [1] is one of the most interesting New England species; and it will well repay careful study. The pink-purple blossoms are arranged on a stem six or eight inches long, rising between two large green leaves. Each flower has a helm-like hood at the top, with a good-sized labellum below

[1] *Orchis spectabilis.*

in front, which serves as a landing-place for visiting bees; and a long tubular nectary (*n*) projecting downwards behind. The hood (*h*) covers the remarkable sexual organs which are just over the mouth of the nectary.



Sectional View of Orchis.

The staminate portions of the flower are developed into two peculiar "pollinia" of the shape of the figure below. These are inclosed in anther cells (*a*), below which is the rostellum (*r*). They are protected by a thin membrane, which splits open at the slightest touch. The two stigmas are situated beneath the rostellum in the position shown at *s* in the illustration above.

Pollinium of Orchis.

Each pollinium when removed from the rostellum is found to consist of a basal piece — the disk — which has a viscid under surface, a stem or caudicle, and an upper portion composed of masses of pollen-grains held together by an adhesive substance. Very soon after the pollinium is removed the stem bends over in such a

way as to bring the upper portion nearly horizontal with the plane of the disk instead of perpendicular to it.

When a bee alights upon the projecting labellum and pushes its head into the mouth of the corolla to

The Showy Orchis.

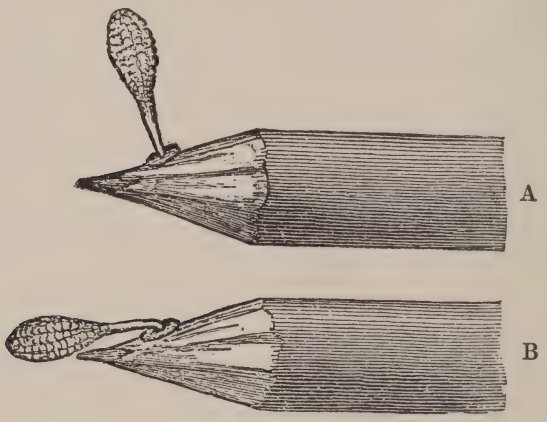
sip the nectar in the nectary, the lower part of the rostellum is ruptured by the contact, and the sticky basal disk of one or both of the pollinia adheres to the head of the bee. When the head is withdrawn

the whole pollinium comes out with it. While the bee is flying about in search of another plant the upper portion of the pollinium curves downward, so that when the next blossom is reached it is projecting in such a way that the pollen-masses will come in contact with the viscid stigma and some of the pollen will adhere to the latter. I have sometimes seen the whole pollinium left on the stigma, but more commonly it remains on the bee's head, so that a single one may fertilize many blossoms.

The structure of our Orchis is very similar to that of the European *Orchis mascula*, the working of the mechanism of which Darwin describes as follows: —

"Suppose an insect to alight on the labellum, which forms a good landing-place, and to push its head into the chamber at the back of which lies the stigma, in order to reach with its proboscis the end of the nectary; or, which does equally well to show the action, push very gently a sharp-pointed common pencil into the nectary. Owing to the pouch-formed rostellum projecting into the gangway of the nectary, it is scarcely possible that any object can be pushed into it without the rostellum being touched. The exterior membrane of the rostellum then ruptures in the proper lines, and the lip

or pouch is easily depressed. When this is effected one or both of the viscid balls will almost infallibly touch the intruding body. So viscid are these balls that whatever they touch they firmly stick to. Moreover, the viscid matter has the peculiar chemical quality of setting like a cement, hard and dry in



A, Pollen-mass when first attached; B, after depression.

a few minutes time. As the anther cells are open in front, when the insect withdraws its head, or when the pencil is withdrawn, one pollinium, or both, will be withdrawn, firmly cemented to the object, projecting up like horns, as shown by the upper figure A. The firmness of the attachment of the cement is very necessary, for if the pollinia were to fall sideways or backwards they

could never fertilize the flower. From the position in which the pollinia lie in their cells, they diverge a little when attached to any object. Now suppose that the insect flies to another flower, or let us insert the pencil (A), with the attached pollinium, into the same or into another nectary. It will be evident that the firmly attached pollinium will be simply pushed against or into its old position, namely, into the anther cell. How then can the flower be fertilized? This is effected by a beautiful contrivance: though the viscid surface remains immovably fixed, the apparently insignificant and minute disk of membrane to which the caudicle adheres is endowed with a remarkable power of contraction, which causes the pollinium to sweep through an angle of about ninety degrees, always in one direction, viz., towards the apex of the proboscis or pencil, in the course of thirty seconds on an average. The position of the pollinium after the movement is shown at B in the figure on page 76. After this movement, completed in an interval of time which would allow an insect to fly to another plant, it will be seen that if the pencil be inserted into the nectary, the thick end of the pollinium now exactly strikes the stigmatic surface.

"Here again comes into play another pretty

adaptation, long ago noticed by Robert Brown. The stigma is very viscid, but not so viscid as when touched by a pollinium to pull the whole off an insect's head or off a pencil, yet sufficiently viscid to break the elastic threads by which the packets of pollen-grains are tied together, and leave some of them on the stigma. Hence a pollinium attached to an insect or to a pencil can be applied to many stigmas and will fertilize all. I have often seen the pollinia of *Orchis pyramidalis* adhering to the proboscis of a moth, with the stump-like caudicles alone left, all the packets of pollen having been left glued to the stigmas of the successively visited flowers."

The European species of Orchis apparently secrete no nectar within the tube of the nectary, but develop it between the outer and inner walls of the tube. The bumblebees pierce the inner wall to get at it. Our Showy Orchis, however, secretes an abundant supply inside the tube, where it often rises an eighth of an inch. If such a nectary is squeezed from in front between the thumb and finger, when the rupture takes place the nectar will be ejected a foot.

The Showy Orchis loves to dwell in rich open woods. In such a grove on the Vermont side of

the Connecticut River I found a beautiful collection of the flowers on the southern exposure of a hill, in full blossom early in June. The plants as a rule stood some distance from each other, the two shining green leaves and the spike of bright flowers making each sufficiently conspicuous to stand alone.

This Orchis is, as Professor Robertson has pointed out, especially adapted to the visits of female bumblebees. The other forms of Bombus have not appeared at the season of blossoming.

A Queen Bombus.

Just above the mouth of the queen bumblebee there is a smooth plate, called the clypeus. To this the disk of the pollinium is attached when the Orchis is visited. The clypeus of the male Bombus is studded with projecting hairs, to which the disk of the pollinium could not become properly attached. Thus this flower affords another instance of perfect adaptation to the minutest structural details of the visiting insect. In Vermont I found the large *Bombus terricola* the most frequent visitor, while in Illinois Professor

Robertson observed *B. separatus* and *B. americanorum* at work upon the flowers.

I also saw one or two Sesia moths flying rapidly from blossom to blossom. The disks of the pollinia probably became attached to the eyes of these moths, of which there are two species common in the Northern States. The larger is the Thysbe Clear-wing,[1] — a handsome insect with head and thorax dark green and brown, and the abdomen with yellow and brown alternating. The wings are transparent in the middle, with dark brown borders. The caterpillars feed upon the leaves of various species of Viburnum. The larva of the smaller species (*H. diffinis*) lives upon the foliage of the honeysuckle.

The Larger Clear-Wing.

A well-known botanist who read the above account has kindly favored me with the following interesting note: "The *Orchis spectabilis* does not always behave as it should. In Northampton, Mass., several years ago, I collected some specimens

[1] *Hemaris thysbe.*

which all turned their pollen-masses the wrong way, up instead of down, and entirely away from the stigma. I put at the time a note into the 'Botanical Gazette' asking for information and other observations. I received but one reply, from Miss Chester of Smith College. Her pupils collected some, and about half of the specimens turned their pollen-masses up and half down. They did not observe whether this depended on the age of the flower."

I regret that my attention was not called to this point in season to make observations concerning it last year. I hope to do so during the coming spring. The facts reported form a good illustration of the danger of assuming that Nature is always uniform in her actions.

VII

THE PINK LADY'S-SLIPPER

No flower in the world, at least no entomophilous flower, can continuously develop healthy offspring without the coöperations of an insect; and multitudes of flowers without such aid could never seed at all. It is to these coöperations that we owe all that is beautiful and fragrant in the flower world. To attract the insect and recompense it for its trouble, a banquet of honey is spread in the heart of the flower; and to enable the visitor to find the nectar, the leaves of the flower are made showy and conspicuous beyond all other leaves. — *Henry Drummond.*

One who has watched the large bumblebees and Sesia moths visiting the comparatively small flowers of the Showy Orchis would naturally take up the study of the beautiful Pink Lady's-Slipper[1] with the expectation of finding so large a blossom pollenized by insects of good size. Bumblebees at least, one would think, should be called to the work. But if before seeing any visitors you study the structure of the flower you will be likely to be puzzled

[1] *Cypripedium acaule.*

The Pink Lady's-Slipper.

to see how the bumblebee gets the honey or carries off the pollen.

The single large and showy flower is borne upon the end of a long stalk which rises between two large green leaves. A good-sized green bract projects upward from the point where the stem curves over behind the blossom. In front of this are the three spreading sepals and part of the petals, while below them is the blossom proper. The most striking part of the latter is the pouch-shaped labellum (*l* in the figure on page 86), projecting forwards and downwards. This curiously shaped organ consists of a large inflated sac, with the front edges inflected in such a way as to form a slit-like opening. Above the labellum — at its upper end — there is a curious organ of the shape represented at *y*. This is a stamen not now functional, but metamorphosed into a petal-like projection. Beneath it is the pistil with the stigmatic surface on the under side (*s*). At *a* are the anthers of the stamens, one on each side.

The stigmatic surface is somewhat viscid, and the pollen is also held together by a sticky substance, making it a pasty mass.

The inside of the bottom of the labellum is furnished with hairs projecting upward and backward.

Many of them are tipped with a glutinous secretion, which is believed to be eaten by the insect visitors. No other signs of nectar are to be seen.

This Lady's-Slipper is pollenized by small bees, — especially those of the genus Andrena and Halictus (see page 10). When one of these, attracted by the showy blossom, comes to the flower it enters

Sectional View of Cypripedium.

the opening in the front of the labellum, and finds itself in a great chamber from which exit by the entrance is impossible. The inflected borders of the mouth of the labellum effectually prevent crawling out there. The bee will finally crawl up by means of the hairs along the path indicated by the dotted line in the accompanying diagram, and go

out at the opening below the anther on one side or the other. In so doing it will pass beneath the stigma, rubbing the latter with its back, and next coming in contact with the viscid pollen of the anther, which will be smeared on the bee's back. If now another flower is visited, when the bee crawls out it will leave some pollen on the stigma and get more pollen from the stamens, so that the fertilization of one blossom by the pollen from another is inevitable.

To catch the Moccason-flower's visitors in the act of pollination is no easy matter. I have watched the blossoms for hours and hours, but only once did I find a guest. That was a small black bee, — apparently a Halictus, — which I saw come out beneath the anthers. But the flowers wait so long for their visitors, and produce such a vast number of seeds when they are fertilized, that if they receive attention only occasionally the species can hold its own in the race for life.

Sometimes one will find a dead bumblebee in the Moccason-flower. It has gone in through the large opening of the labellum, has been unable to escape the way it came, and, crawling upward, becomes imprisoned beneath the stigma, where it finally dies. Such a tragedy is represented in the frontispiece.

The structure of the Lady's-Slipper blossom is such that the visiting bee must furnish pollen from another flower if it leaves any. In the light of our present knowledge this seems natural and reasonable, but in the morning dawning of a century ago — when beauty was "its own excuse for being," and blossoms were borne for man — neither the necessity nor the significance of such an arrangement was perceived. The fatal flaw in Sprengel's work was here. He rightly believed that the color, odor, and nectar of flowers were for the purpose of attracting insects which served as pollenizers; but he failed to distinguish with sufficient definiteness between fertilizing a blossom with its own pollen and that from another plant. As is often the case when a partial truth possesses a man, he was in a position difficult to hold: on the one hand, his critics could show that in many flowers the stamens or pistils were so arranged that self-fertilization took place without the aid of insects; and, on the other, that in many blossoms these organs matured in such a way that the bees could not furnish the pistil with pollen from the stamens beside it. Sometimes the pistil withered before the pollen matured, or *vice versa*. Sprengel by no means attempted to show that all flowers were self-pollen-

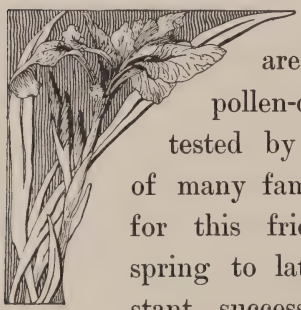
ized, for he saw that in many blossoms the pollen must come from another flower; but he failed to distinguish between the value to the plant of self- and cross-fertilization, so that his reasoning had not the cogency it at once assumed when many years later it was proved "that cross-fertilization results in offspring which vanquish the offspring of self-fertilization in the struggle for existence." [1]

[1] See page 36 of this book. For a sketch of the development of our knowledge of the subject, see Müller, *Fertilization of Flowers*, Part I.; also, W. H. Gibson's article in *Harper's Magazine*, March, 1894.

VIII

THE FRINGED POLYGALA

Botany and entomology must henceforth go hand in hand. The flower must be considered as an embodied welcome to an insect affinity, and all sorts of courtesies prevail among them in the reception of their invited guests. The banquet awaits, but various singular ceremonies are enjoined between the cup and the lip. — *Wm. Hamilton Gibson.*



The fact that bumblebees are among the most efficient pollen-distributers is abundantly attested by the extent to which plants of many families have called upon them for this friendly office. From earliest spring to latest autumn there is a constant succession of blossoms that cater especially to these bees, which are always ready for new hosts if they yield the nectar and pollen the bees so diligently seek. In late spring and early summer the Fringed Polygala[1] is one of the most attractive of these hosts. It abounds in sparse pine woods and on open hillsides, holding its pretty blossom heads above the fallen leaves to attract

[1] *Polygala paucifolia.*

the attention of the passing bee. The flowers are of a beautiful rose-pink color. The two upper

The Fringed Polygala.

sepals have been developed into spreading petal-like wings, which with the three peculiarly shaped petals go to make up a very irregular blossom.

The lower petal is tipped with a pretty fringe, behind which is a two-valved pouch — the keel — wherein the pistil and stamens lie.

The structure of the style of the pistil is worthy of special notice. At the outer end is a spoon-shaped tip which lies below the anthers in such a way that when the surrounding petal is pressed downward the spoon pushes the pollen out through the slit at the top. The stigma is situated at the side of the spoon toward the base of the blossom.

By watching a bed of Polygalas on a bright day, one can easily see how this apparatus works. A bumblebee visits the flower, using the mass of fringe as an alighting board. The weight of its body depresses the keel, and the spoon-tipped pistil pushes out the pollen, which is brushed upon the abdomen of the bee. After a few such visits the pollen is exhausted, and bees visiting the blossoms thereafter come in contact with the stigma, on which they brush the pollen received from other flowers. The nectar is so protected by the closely appressed petals that few insects can get at it, and the pollen is not visible until the keel is depressed, so that it also is protected from being wasted by useless visitors.

Similar methods of guarding the precious nectar

from pilfering wanderers have been adopted by many plants. A striking example of such protection is furnished by the Closed Gentian.[1] The large conspicuous blue or blue and white flowers remain apparently closed. At the tip the corolla has five short lobes which overlap one another in such a way as to leave no opening: an ant even could not pass between them. To the uninitiated it would seem that this must be a self-pollenized blossom, and the wonder would be why so elaborate a flower was ever developed. But the bumblebees can tell you better. They know the combination which opens the portals of the flower.

One beautiful October noon I was lunching beside a small stream in the Granite State, in the midst of a bed of Closed Gentians. A bumblebee came along and lit upon a cluster of asters. Leaving these it next visited a head of gentians, and with some difficulty thrust its tongue through the valves of the nearest blossom; then it pushed in its head and body until only the hind legs and the tip of the abdomen were sticking out. In this position it made the circuit of the blossom, and then emerged, resting a moment to brush the pollen from its head and thorax into the pollen-baskets,

[1] *Gentiana andrewsii.*

before flying again to a neighboring aster. The whole process required about twenty seconds. After plundering the aster, the bee invaded another gentian in the same way; then it visited another group of asters and departed across the river.

Wondering why the bee had selected only one of the five blossoms in the last visited cluster of gentians, I examined them all. There was only one young flower in the lot, and that was the one visited by the bee. In this the mouth of the corolla was white against a light blue background. The older blossoms were darker blue, with the white markings minute and indistinct. Subsequent observations confirmed me in the opinion that by means of this difference the bees are able to select the younger, nectar-bearing blossoms without wasting time in uselessly exploring the interiors of the older ones.

It is worthy of note that this Gentian, while it inhabits localities where ants are abundant, has no hairs or other methods of preventing their visits except by keeping the corolla closed.

On the lower portions of the Polygala stems — especially where they are covered by fallen leaves — there are nearly always a few small, green, inconspicuous bud-like developments, which on examination prove to be rudimentary blossoms. They do

The Closed Gentian.

not open at all but have dwarfed stamens and pistils from which seed are produced. Some of these "blossoms" are shown at *a* in the illustration on page 91.

Such closed blossoms as these are found on many plants, and were called by Kuhn many years ago cleistogamic flowers. They form the subject of an interesting chapter in Darwin's volume on "Different Forms of Flowers on Plants of the Same Species." Concerning them the great naturalist says: —

"They are remarkable from their small size and from their never opening, so that they resemble buds; their petals are rudimentary or quite aborted; their stamens are often reduced in number, with the anthers of very small size, containing few pollen-grains, which have remarkably thin transparent coats, and generally emit their tubes while still inclosed in the anther cells; and, lastly, the pistil is much reduced in size, with the stigma in some cases hardly at all developed. These flowers do not secrete nectar or emit any odor; from their small size as well as from the corolla being rudimentary they are singularly inconspicuous. Consequently insects do not visit them, nor if they did could they find an entrance. Such flowers are

therefore invariably self-fertilized; yet they produce an abundance of seed. In several cases the young capsules bury themselves beneath the ground and the seeds are there matured. These flowers are developed before, or after, or simultaneously with the perfect ones. Their development seems to be largely governed by the conditions to which the plants are exposed, for during certain seasons or in certain localities only cleistogamic or only perfect flowers are produced."

The fact that conditions largely determine the nature of the flower is well shown in Polygala. The exposed flowers as a rule are large, showy, and perfect; those hidden beneath fallen leaves or other materials are small and cleistogamic. Between these extremes various gradations may be found. My observations indicate that the development of the blossom is very largely determined by the amount of sunlight it receives.

Few blossoms show more extraordinary modifications to insure cross-pollination by bumblebees than those of the genus Iris. In these blossoms the style of the pistil is developed into a petal-like expanse with the stigmatic surface on the under side. The other floral organs are so arranged that the bee coming for nectar brushes

The Blue Iris.

past the stigma, leaving pollen upon it, and comes in contact with the anthers to receive a new supply of the golden dust.

One beautiful June morning I started out to study Iris. It was one of those early summer days in which birds and insects seem especially to delight. Skippers of many kinds were out in force, and the glorious *Papilio turnus* lazily flitted along the road beside me, stopping now and then to sip at a clover blossom. Every few steps I flushed a coral-winged locust and watched its rapid irregular flight, producing the effect of a flash of red which disappeared the instant the insect alighted. Occasionally a brilliant green tiger beetle hied his shining body from beneath my feet, and in the woods on either side the warblers and thrushes were chanting the love-songs of early June. Soon I came to a marshy meadow in which was a large bed of the Blue Iris. Here was the opportunity I had desired, — an opportunity to observe a scene in the old, but ever new, drama which has run so many successful seasons, — The Development of Iris.

The curtain was up as I entered the theatre, and the stage was set in a glory of yellow buttercups, contrasting with a background of the varying

greens of grass and shrub and tree. Above was the faint blue of a slightly misty sky. I ushered myself to a box seat upholstered in violets and bluets woven in a velvety moss. The bill of the play was not handed me, but I did not mind, because being the only member of the audience I did not have my attention distracted by the necessity of ogling my neighbors, and could devote all my wits to interpreting the pantomime.

The rôle of the leading lady was taken by the fair Iris herself, but instead of a single star and an indifferent support, there were hundreds of the leading ladies, each as beautiful as the others. There they stood, a graceful and glorious throng, each full of sweetness and extending an alluring invitation to the many flying insects abroad enjoying the June sunshine.

I soon saw that many courtiers were present to pay their devoirs to my lady Iris. There on the front of the stage is a splendid bumblebee, — a favored suitor, who alights upon the expanded petal, crawls down beneath the style and stamen, and sips the nectar. In so doing it brushes against the stigmatic surface, and leaves some pollen from a previous flower. Then it backs out, carrying with it pollen from the present blossom, and flies rapidly

to a neighboring Iris, there to repeat the process. The Iris seems especially adapted to bumblebees, and it is quite commonly supposed that these are the most numerous visitors. Consequently I was surprised to find very few of them present.[1] A good-sized syrphid fly — apparently a species of Rhingia — was much oftener seen going in and out the nectar passage, and bees smaller than bumblebees occasionally paid their respects to one of the blossoms. But I was most surprised at the number of gay and brilliant courtiers fluttering about the blossoms to steal sweets to which they had no right. Butterfly skippers of many kinds lit upon the middle of the blossoms, and thrust their slender tongues through narrow openings, which led to the nectar. The larger clear-wing [2] was present in numbers. One would occasionally enter the nectar passage, and act as a pollinator, but nearly always they simply sucked the nectar from between the lobes of the perianth. The beautiful abbot sphinx also partook of stolen sweets, and even the great deilephila sphinx did not disdain a similar offense. It is fortunate that

A Skipper.

[1] The most abundant species was *Bombus terricola.*

[2] *Hemaris thysbe.*

the Iris lives in wet places, where there is abundant water with which to manufacture nectar; otherwise it would be very apt to suffer from such a drain upon its supply of that useful product.

This nectar robbery of Iris is not so serious, however, as it is in the case of many other blossoms. The visitors simply pilfer the sweets without injuring the structure of the flower. But many blossoms are less fortunate, as is notably the case with the beautiful Columbine of our hillsides. This flower is adapted to pollination by hummingbirds and bumblebees; the latter light upon the front of the blossom, and thrust in succession their long tongues down each of the five nectar-tubes. This is the legitimate way for the bumblebee to act, for thereby the cross-pollination of the flower is insured. But many bumblebees have learned that the nectar is easily reached by biting through the nectar spurs without visiting the front of the blossom at all, and they act accordingly. I have seen hundreds of the blossoms ruined in this way, and have seen a number of bumblebees engaged in the work of destruction. When a bee learns this method of getting nectar it generally does not trouble itself to take it in the legitimate way. A great variety of blossoms are thus robbed of the nectar by bumblebees.

The Canada Lily.

IX

THE CANADA LILY

To meet the case of insects which love the dusk, many flowers are colored white ; for those which move about at night and cannot see at all, the night-flowers load the darkness with their sweet perfume. The loveliness, the variegations of shade and tint, the ornamentations, the scents, the shapes, the sizes of flowers, are all the gifts of coöperation. The flower in every detail in fact is a monument to the Coöperative Principle. — *Henry Drummond.*

No plant gives greater glory to the lowland meadows of New England than the Canada Lily.[1] It is exceedingly beautiful as it waves its gorgeous blossoms above the grass of the surrounding meadow ; and when, as often happens, several vigorous plants grow near together,

> "Flushing with tender bloom the pastures wide,"

they appeal to the flower-lover very potently, even though the farmer may not value them as an addition to his hay crop.

[1] *Lilium canadense.*

This lily is pollenized by bees, especially the peculiar members of the genus Megachile, — commonly known as leaf-cutter or upholsterer bees. They are quite abundant in New England during the summer months, and visit a great variety of blossoms in quest of nectar and pollen. They

Cross Section of Canada Lily.

alight upon the down-hanging pistil and stamens of the Canada Lily, which are so arranged that the bees prove efficient pollenizers. The bright orange of the lily sepals, with spots of contrasting brown, effectively advertise the floral attractions to these bees, which dearly love a shining mark.

Megachile's life-history is full of interest. The masses of dark pollen which she gathers from the lily are not for her own use, but rather for the nourishment of the little "Megies," — as helpless

The Leaf-Cutter Bee.

as human babies, — which in some snug cranny are coming into the world. Before the pollen-gathering process began, the mother bee chose a nesting site, — perhaps burrowing a hole in the ground or gnawing a channel in soft wood. Having selected the site and made the excavation, she flew to a rosebush or some other plant with foliage of firm texture, and gnawed out a semi-circular piece of leaf which was carried to the bottom of the opening. Other pieces of leaves followed the first one, and were fashioned into a cup-like cell, which was filled with the pollen-food, and in which an egg was laid. Then the cell was capped with a circular piece of leaf, and another was placed above it. This process may be continued for three or four weeks, and the same female bee may thus provision thirty or more such cells.

The eggs deposited within the leafy cups soon hatch into little footless grubs that feed upon the food with which they are surrounded. They grow, and as they grow they shed their skins, — a new one appearing each time the old one is sloughed off. Finally they become mature, change to pupæ, and emerge as adult bees.

The pollen-collecting arrangements of Megachile are worthy of notice. The bees which heretofore

we have had to consider have used their legs as pollen-collectors, some of them having beautifully developed pollen-baskets on the hind pair. But with Megachile, things are managed differently: the whole under surface of the abdomen is one great pollen-basket in which the pollen-grains are held in place by means of long hairs with which the surface is thickly beset. These bees, when visiting thistles or similar composite plants, move their abdomens from side to side while they are sucking the nectar, and thus with very little trouble they force the pollen-grains in between the hairs. This combination enables them to collect nectar and pollen with extraordinary rapidity.

An interesting comparison may be drawn between the Canada Lily and the beautiful Bermuda or Easter Lily.[1] The former is of a bright orange-color; its blossoms hang downward; it is fertilized by day-flying bees. The latter is pure white; its blossoms are horizontal; the stamens and pistils are so arranged that it must be pollenized by long-tongued moths. Both belong to the same family, but one has catered to day-flying insects which love bright colors and an abundance of pollen, and the other to night-flying or crepuscular moths. The

[1] *Lilium harrisi.*

whiteness of the latter and the odor which it especially emits at nightfall attract to it the long-tongued sphinges which care for nectar rather than pollen. These moths do not have to store up food for their

Cross Section of Bermuda Lily.

young; instead they simply deposit their eggs upon the green surfaces of plants, and leave the resulting caterpillars to shift for themselves.

The adaptation of the Bermuda Lily for pollination by sphinx moths is easily seen. If you remove one side of the white flower-cup you will

see that the pistil consists of a long style running the whole length of the flower, with the sticky stigma at the end. Grouped on the sides are the

The Five-Spotted Sphinx.

stamens, which also have long filaments tipped with the anthers at the mouth of the flower. Evidently no ordinary insects can get the nectar at the base of the cup: the sphinx moths are the only ones adapted to derive benefit from such a blossom. But for them the adaptation is perfect. The tongues of the larger species will reach the honey, while their heads come in contact with the anthers or stigmas and perform the pollenizing office.

These moths are not day-fliers: they appear at

dusk, and during the early evening they shoot like meteors from blossom to blossom, hovering hawk-like at the mouth of the flower, while the long tongue is inserted to extract the hidden nectar. The immaculate whiteness of the lilies renders them conspicuous in the twilight; they then shed their perfume most abundantly, and, in some species at least, produce the most nectar. These methods the lily has developed to attract her pollen-carrying guests. The latter also have assisted in the adapta-

The Achemon Sphinx.

tion: their long tongues, the shape of their heads, their large eyes, all are useful to the lily, while the swiftness of their flight and the business-like way in which they utilize the few hours during which they

are abroad enable them to pollenize a large number of blossoms in a short time. "The Sphingidæ," says Hermann Müller, "perform their work as fertilizers, peculiarly rapidly, dropping their long proboscis into a flower while hovering over it, and instantly hastening away on their violent flight to another. Accordingly most nocturnal flowers have

Sphinx Pupa.

adapted themselves especially to these Lepidoptera, hiding their honey in such deep tubes or spurs that it is only accessible to the Sphingidæ."

In considering the relations of floral odors to insect visits, we must bear in mind that there are good reasons for believing the sense of smell in insects to be vastly more acute than in ourselves. When we remember that insects can see colors beyond our range of vision, and hear sounds inaudible to us, we are ready to accept the statement of their extraordinary acuteness of smell. The evidence on this point is conclusive. Entomologists have long been familiar with the process of "assembling"

in the larger moths. If one confines a female of the larger silk-moths — like the cecropia, the polyphemus, or the promethea moth — freshly emerged from the cocoon in a room with the window open, a number of the males of the same species will very likely be attracted. Many of these, one must suppose, were a considerable distance off when they became aware of the existence of the female. It is evident also that they could not have been attracted by sight or hearing, but by the sense of smell. The antennæ of these male moths are extraordinarily developed, and to this fact is generally attributed their unusual keenness in this respect.

An interesting experience with our handsome *Telea polyphemus* has been recorded by Professor H. Garman of Lexington, Kentucky. He says: "In the latter part of July, 1893, a fine female *T. polyphemus* emerged in one of my breeding cages. She came from her cocoon in the afternoon, and by night her wings were pretty well expanded. I thought when I went home at five o'clock that her wings were not sufficiently firm for a good cabinet specimen, and so she remained in the cage until next day. In the evening of the following day cage and moth were taken to my home, and mosquito-bar being tacked over the

front of the cage the latter was placed in the open window of my bedroom. In the night I was awakened by the fluttering of wings against the window and curtains, and getting up secured the two first males that had appeared. It was then just 1.30 A. M. From this time until daylight the males continued to come, sometimes two or three arriving about the same time, but oftener one at a time. All that appeared were captured, and in the morning I found I had twenty males, most of them nearly or quite new in appearance." The next night twenty-three more males were caught, and during the succeeding three nights enough to make a total of fifty-two male moths captured in a locality where this usually rare moth is not more than ordinarily common. Evidently the males of the species must either cover surprising distances in their nocturnal flights, or else they must be able to discern from afar the presence of the other sex.

If the stories of the geologists are true, there was once a period in the earth's history when plants existed with no insects to prey upon them. But there were also no insects to carry the pollen from blossom to blossom, and the plants were perforce either self-pollenized or dependent upon the

wind for the distribution of the pollen. The wind is a very wasteful messenger to send on such an errand; it spills a thousand pollen-grains while carrying one to its proper destination. As the æons of geologic history passed, the lower insects appeared. Some found the pollen of the then existing blossoms good for food and nibbled at it, just as to-day wind-pollenized blossoms are often visited by insects. Some such blossoms gradually became entomophilous, as with our willows. Other blossoms which at first were small, greenish, and self-pollenized, were occasionally visited by insects and cross-pollenized. The progeny of these cross-pollenized flowers would be stronger than those from self-pollenized ones, and would crowd them out in the struggle for life. Moreover, if we are to accept some of the more probable of the recent expositions of heredity, there would be a greater tendency to vary because of two parents. The tendency to vary was then, as it is now, of value to the species in enabling it to adjust itself to a slowly changing environment. But especially in the early history of the flowering plants such a tendency must have been of great advantage. Every blossom that became more conspicuous than those around it was more likely to receive insect visits,

and to be cross-fertilized. Consequently any variation leading to greater showiness was acted upon by the conditions of life, and was likely to be perpetuated. If stamens changed to petals or bracts became showy, a point was gained in the race for existence. So the great floral drama went on through countless ages of time, before man was made in the image of his Maker. After the swamps of the carboniferous period had become dry land, and the frightful monsters of the reptile kind had disappeared, Mother Earth entered upon a less gruesome era in the long pregnancy which led to the birth of man in a world fitted for his kingdom. The development of modern animals began. The insects and flowers adapted themselves more and more to each other. Throughout the world the mountains and valleys, the woodlands and prairies, witnessed the constant struggle toward perfection. How the fancy runs riot in thinking of those prehistoric fields, where the bees and butterflies accepted the invitation of the nodding blossoms, — where possibly the children of the cave-men, in a language long since lost, ran screaming to their mothers at the ponderous approach of mastodon or of mammoth, — the giants of those days !

But even when man attained the dignity we find

in him at the beginning of the historic period, the struggle among his lowly relatives did not cease. In a vague and misty way he himself began the long struggle toward perfection which ever since he has been bravely keeping up, — in the populous city and the lonely hermitage, on the mountain and in the desert, beside the running waters of joyous life and beneath the shadows of sin and death. Always and everywhere man has struggled upward, attempting ever better to adapt himself to the conditions of his existence. And beside him there have always existed and always shall continue to exist the myriads of organic beings perpetually struggling to a more perfect adaptation to their surroundings. But with them — so it seems to us at least — the problem of life must be different. With the light of a higher reason and an enlightened self-consciousness we have in our struggle factors unlike theirs. But these lowly relatives may show us that we struggle not in vain. The beauty of the spotless lily — the result of countless ages of the struggle for existence — may well serve man as the emblem of purity and strengthen his faith that "all 's well with the world."

X

THE COMMON THISTLE

Those old days when the balancing of a yellow butterfly over a thistle bloom was spiritual food and lodging for a whole forenoon. — *Lowell.*

If the flowering plants should ever hold a convention for the purpose of signing a declaration of independence, and in the preamble should insert a statement to the effect that all plants are created free and equal, they would be as wide of the mark as were our forefathers when they made a similar assertion concerning the human species. In the constant struggle for existence to which all plants are subject, some species are so much better provided with the weapons of war than others that when they come into competition they must perforce crowd the latter to the wall. A striking instance of this condition of things was seen in the Central States a few years ago when the Prickly

The Prickly Lettuce, reduced.

a, stem and leaves; *b*, floret; *c*, seed.

Lettuce[1] — a well-endowed immigrant — invaded the land. I have not been able to learn precisely when this species was introduced into America. It is not included in the 1866 edition of Gray's Manual of Botany, but in the Synoptical Flora, published in 1884, it is mentioned as "becoming common" in the Atlantic States in gardens and around dwellings. In the sixth edition of the Manual (1890) the plant is reported as occurring in waste places and along roadsides from the Atlantic States to Missouri, — a rapid spread in six years. But probably in 1884 it had already entered many states away from the Atlantic coast. It certainly occurred in Ohio in 1879, having been collected that year in Toledo and Painesville; and a few plants were found in the vicinity of Columbus in 1882, after which time the species increased very rapidly. In 1891 it occupied a large portion of the commons and waste fields about Columbus, having crowded out nearly everything before it. There were then many fields of several acres each in different parts of the city where the plants averaged three to the square foot. The same was true of many other parts of Ohio.

The Prickly Lettuce is a composite plant growing

[1] *Lactuca scariola.*

to a height of two to six feet (probably averaging between four and five), with narrow open panicles of small yellow flowers. The leaves are pale green, sagittate, and have a row of stiff prickles along the under side upon the midrib. They are usually twisted into a more or less vertical position. Few plants are better prepared for survival. The stem is solid and furnished with a milky juice. Its solidity enables it to become erect again when trodden upon, and, combined with the milky juice, protects it from insect borers; while the prickles on the stem and leaves are a protection from herbivorous mammals. The seed is provided with a fine pappus enabling it to be carried easily long distances by the wind. Each plant produces a large number of seeds. One of my assistants estimated, after a number of counts, that each plant produced, on an average, 688 heads, with an average of 12 seeds to the head, or 8,256 seeds to the plant. With three plants to the square foot, this gives 3,234,453,120 seeds to the acre. No wonder its course is so rapid and resistless!

The United States is full of such sturdy usurpers from beyond the seas. Perhaps none of them is more vigorous or better able to hold its own in the race for life than the common Thistle, *Cnicus lanceolatus*. This species is provided with many

means of defense from the ills which plants are heir to. Its spiny leaves and blossoms make it inedible to nearly all animals; the toughness of

The Common Thistle.

the stems enables them to endure an amount of trampling that would be fatal to most plants; its

seeds are beautifully adapted to wide and rapid dispersal, and its habit of growth gives it additional advantages.

Our principal interest at present, however, centres in the blossoms, in which respect, also, the thistle is well provided. Like the other composites, it has adopted the plan of having many flowers crowded together in a single head, — an arrangement which has many advantages, especially that of economy. If you pull a thistle blossom apart you will find it composed of a large number — often a hundred or more — of individual florets crowded together on a common base. Each floret consists of a slender cylindrical corolla tube, nearly an inch long, within which are the stamens and pistil. The anthers of the stamens are united into a tube within which the pollen is developed before the pistil matures. This pollen is pushed out from the upper opening of the anther cylinder by the style of the pistil as it lengthens, so that in the first stage of blossoming the pollen is present, and the pistil is hidden away in the anther tube. As the pistil matures it finally pushes clear beyond the tip of the anther tube, — the pollen meanwhile having been mostly carried away by insects, — so that in the second stage of the floret's existence the

pistil is visible, while the pollen has largely disappeared. The upper part of the style is thickly beset with small hairs; and the stigmatic surface runs along the side.

The pollen of the thistle is admirably adapted to the structure of the pistil, as well as of the insect visitors. Each pollen-grain is so studded with sharp projections that it adheres readily to hairs on the insects or the pistil.

The list of visitors to the common Thistle is an extended one. In conspicuousness, if not also in frequency of visits, the bumblebees take the lead among the Hymenoptera. But they are not the large and handsome bees found on the Arbutus in May: they are much smaller in size and less attractive in appearance. This difference is explained by a glance at the life-histories of the bumblebees. The large specimens which appear in spring are the hibernating females or queens, which have passed the winter snugly ensconced in last year's nests, or some other sheltered situation. In spring as soon as the sun has thawed out their retreats, and the early blossoms appear, they sally forth in search of a nesting site, commonly choosing a deserted mouse nest, or a mass of dry grass beneath a stump, log, or other shelter. Having selected the

site, the bee next makes for a part of it a waxy lining, or a sort of a receptacle. She then visits the early blossoms in quest of nectar and pollen, sucking up the former to carry it to the nest, and loading the latter into the pollen-baskets on her legs. In the nest the honey and pollen are placed in the receptacle and mixed into a pasty mass, on which, when enough has been accumulated, the bee lays her eggs. In a short time the eggs hatch into little footless larvæ, which feed upon the "bee-bread" around them, rapidly increasing in size, and generally working away from each other, so that by the time they are full-grown each larva occupies a hole in the food mass. Each then spins a thin silken cocoon within which it changes to the pupa state, to emerge a little later as a fully-developed bee; but it is very much smaller than its mother, and is known as a "worker" or "neuter" bee. Upon it soon devolves the work of gathering honey and pollen, and most of the affairs of the Bombus household, for as soon as a sufficient number of these youngsters are developed, the queen bee remains at home and does little but deposit eggs. Cells of wax are made, some of which serve as receptacles for eggs, others for honey and pollen. In some species, at

least, the worker bees feed the larvæ with a mixture of honey and pollen, which they prepare daily. In the species in which this habit has been best observed two sizes of workers were present: the smaller ones fed the larvæ and attended to the internal affairs of the household, while the larger ones furnished the supplies.

The worker bees continue to develop throughout the summer, during the latter part of which there is also produced a brood of young queens and of males. In autumn all forms but the young queens perish: these survive the winter, and the following season continue the propagation of the species.

The bumblebees visit the thistle to get both nectar and pollen. When one lights upon a thistle blossom it thrusts its long tongue down into the florets again and again before the plundering is completed; when so engaged it is easily captured by placing the mouth of the cyanide bottle over it.

The thistle attracts many other bees to its blossoms. Megachile is a frequent visitor, collecting in great quantity the abundant pollen on her abdominal brushes. The beautiful steel blue or green bees of the genus Agapostemon are common, and various smaller species often occur.

The two-winged flies of the order Diptera rank

next to the Hymenoptera in frequency of visits, although perhaps the butterflies are equally numerous. The flies are nearly all after pollen rather than honey, belonging usually to the large and brilliant family of Syrphids. These flies have varied life-histories, but the majority of the common species feed upon aphides or plant-lice when young, and pollen when adult. The fly deposits its peculiar white eggs on leaves or twigs where plant-lice abound. The eggs soon hatch into footless larvæ with pointed heads, by means of which they transfix the helpless plant-lice, and suck out their juices. A single syrphid larva may thus destroy a large number of the aphides. When full grown as larvæ they pupate and soon emerge as pollen-feeding flies. These syrphids are also of interest because of the way in which they mimic the four-winged bees and other Hymenoptera, which nature has provided with a sting. The flies lack this useful organ, but in many cases they so closely resemble stinging insects in the same locality that they must get credit for the possession of a sting, and so escape persecution by birds. In the accompanying illustration a photograph is reproduced representing four Hymenoptera (on the left) and four flies (on the right) common at Hanover, New Hampshire. The resem-

Mimicry of Bees and Flies.

blance even in this illustration is quite striking; in the dead specimens it is still more so; while in the living, flying individuals it is practically complete. I have again and again captured one of these flies, taking care lest I be stung, only to find when the cyanide fumes of the collecting bottle had laid the specimen low on the bottom that the supposed sting belonged to another species.

Many butterflies visit the thistle blooms. An hour's watching on a bright day is sure to show half a dozen or more species. The common yellow butterflies — *Colias philodice* — will probably be most numerous, for this species especially abounds in those localities in which the thistles develop. "Where philodice is found no one can have failed to notice it, either in garden or field, as it gently flits from flower to flower, or courses along the road or across the meadow, with sustained and wavy flight. It is sociable and inquisitive, and may often be seen to stop in mid-career as it overtakes or meets its fellow, the two fluttering about for a moment and then speeding on their

The Yellow Butterfly.

ways ; or they mount in air, approaching, retreating, with a slow, vertical, and tremulous ascent, till the eye ceases to follow them. When the clover is in blossom the meadows are gay and animated with these yellow butterflies, and wherever bright flowers are, will surely be seen philodice. On marigolds and brilliant single zinnias they delight to pasture, for they have a keen sense of color. I have known one of them to alight on an amethyst in a lady's ring, after hovering about its wearer so persistently as to attract attention, and it rested some seconds. Doubtless there were puzzled perceptions on sounding that stony flower." [1]

Philodice deposits her eggs on the leaves of clover. The resulting caterpillars feed also upon this foliage, at first gnawing a hole in the leaf and then devouring the exposed edges. They become full grown in three or four weeks, and change to chrysalids beneath the protecting surface of some stem or board, emerging a little later as full-fledged butterflies. There are generally three broods in a season.

Philodice, as well as the various other butterflies that visit the thistle, — including the white cabbage species, the archippus, the various argynnids, and

[1] W. H. Edwards.

Some Thistle Butterflies.

many skippers, — is after nectar. The butterflies are nectar-sippers, not pollen-feeders. Their long coiled tongues fit them to gather nectar from floral cups of many forms.

One would think that the thistle was effectually protected from uninvited guests, but several species of ants manage to crawl over the prickly thorns and thrust themselves down between the florets. They are comparatively rare, however, and doubtless do little harm.

In the preceding pages I have attempted to indicate a few of the points of interest revealed by ten of our common blossoms. A study of almost any other ten flowers would have shown as many interesting facts. Should any reader care to observe them for himself he will find a field rich and ample, in which the workers are just beginning to reap the harvest. He should study carefully Müller's classic "Fertilization of Flowers," and Darwin's various works, to learn what observers in other lands have recorded. In our own country a little was accomplished by Dr. Asa Gray and others, but no systematic investigation along the lines laid down by Müller was begun until Professor Charles Robertson of Illinois took the subject up

several years ago. He has worked diligently at it ever since, publishing his results in the "Botanical Gazette" and the "Transactions" of the St. Louis Academy of Science. A charming article by Wm. Hamilton Gibson, in which a general survey of the subject is given, may be found in "Harper's Magazine" for March, 1894; from it I took the lines on page 90 of this book.

A plant is not to be studied as "an absolutely dead thing," but rather as a sentient being with "the potency of life in it to be as active and as vigorously productive" as the surrounding conditions render possible. To measure petals, to count stamens, to describe pistils without reference to their functions, or the why and wherefore of their existence, is to content one's self with husks in the presence of a feast of fatness, — to listen to the rattle of dry bones rather than the heavenly harmonies of life. We have reason to be profoundly thankful for the signs to be seen on every side that the dreary stuff which was called botany in the teaching of the past will soon cease to masquerade in its stolen costume, and that our children and our children's children will study not dried specimens or drier books, but the living things which Nature furnishes in such profusion.

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